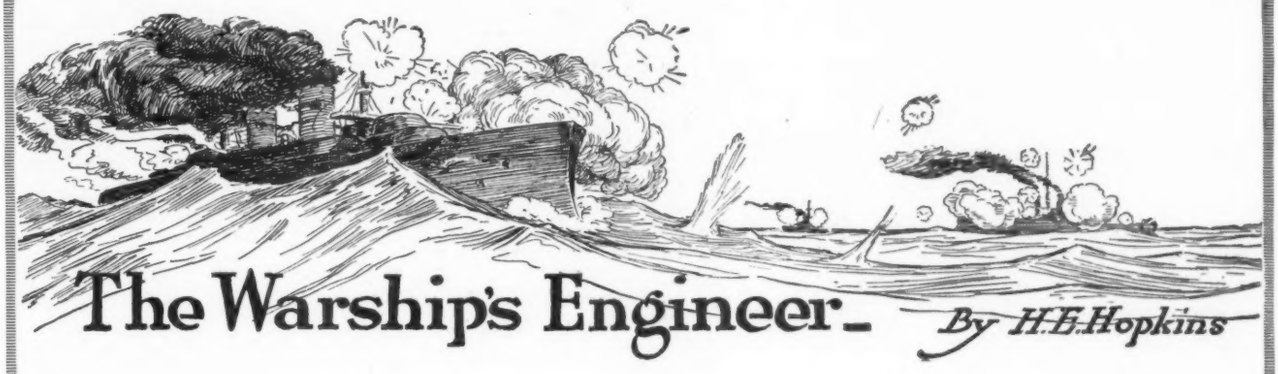
POWER

Vol. 40 NEW YORK, DECEMBER 8, 1914 No. 23

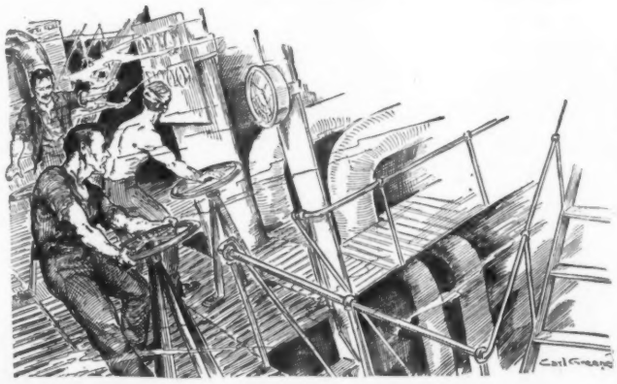


The Warship's Engineer

By H. E. Hopkins

WHO is it in dread war's fell strife
That looms so large in death, in life,
As he whose post is far below,
'Midst hissing steam and furnace glow?
The warship's engineer.

Who is it calm and steady stands
And works where Duty's stern demands
Make him a helpless victim there
That those on deck may do their share?
The warship's engineer.



Who is it when the stricken craft
Is dealt a blow that, fore and aft,
Upheaves and rends her, marks her doom—
Who "stands by" in the engine room?
The warship's engineer.

Who is it when the tale is told
Of brave deeds done by sailors bold
Has "gone down with his ship" to save
His fellows from a deep-sea grave?
The warship's engineer.

Who is it in dread war's fell strife
Should get from us in peaceful life
Due meed for work that WE well know?
On whom shall we our praise bestow?
The warship's engineer.

Equipment and Methods in Largest Refrigeration System—I

By Charles H. Bromley

SYNOPSIS—Describing the design and operation of equipment in the Sargent's Wharf station of the Quincy Market Cold Storage & Warehouse Co., Boston, Mass. The company has a total rated capacity of 4000 tons daily, the station having a 1000-ton compressor, the largest ever built and embodying most interesting features of design. The system is in two parts, a warehouse system having seventeen large houses and a street system having six miles of piping and supplying 800 separate services. In hot weather as much as 50,000,000 gal. of brine is circulated daily. Every possible precaution is taken to insure continuous service the year around, for service interruptions here are as much to be feared as those in electric central-station and in railway practice.

Introductory

Millions of dollars is a lot of money. When invested in perishable foodstuffs, the market value of which fluctuates, and supplying the most densely populated section of this continent, the problem of preserving these products is one of great economic and engineering importance. We will consider only the engineering part of the problem.

Right here, the writer wishes the reader to understand that in this plant uninterrupted service is paramount. To shut down is unthinkable.

Service is sold on a guarantee that the temperature will not vary more than one degree. Suppose the plant fails only for a short time in summer; then the temperature rises and hundreds of thousands of dollars' worth of produce may be ruined. The dealer can claim damages for his loss, and there is always the possibility that, should the service fail and the temperature rise considerably at a time when the market value of the produce is going down, with every indication that it will not rise soon, the dealer might sue, claiming injury to his produce, and thus try to recover a loss or avoid an impending one. Where over 800 customers are served on the street system alone and seventeen large warehouses are filled with perishable goods, the damages due to service interruptions would be large.

Service interruptions are as much to be feared as in electric central-station or railway practice, either of which can drop its load and pick it up where it dropped it. A refrigeration station cannot do this. The moment service ceases, the temperature begins to increase, and by the time the plant is again in service, the temperature may have risen so high as not only to damage the goods, but—and here is the point—to require hours to get it back to normal.

Differing from electric or railway station practice, the load is practically constant 24 hours a day for whole seasons. From the viewpoint of overall station economy, this may be desirable, but where real estate values are high and the station's capacity is none too great for the maximum demand, the equipment must go into service prepared for a nonstop run of months. Every feature of operation, every detail of design must be planned to this end, and should an accident occur, the exigencies demand that the crew be capable of getting the machine back into service with the least possible delay, which means that it must be, to a great degree, independent of outside aid except for very exceptional cases.

All this is mentioned because features of design and peculiarities of practice will be considered that may, without having in mind the nature of the service, be thought extreme and unjustified.

The Sargent's Wharf Station

As you take the old South Ferry for East Boston, at the foot of Eastern Ave., you see little to indicate that, at the rear of the great warehouse on Atlantic and Eastern Aves., is the "heart" that keeps alive the greatest of refrigeration systems. It is there, however, and embodies many of the most interesting things in power-plant practice that the writer has ever seen.

This plant has a total refrigeration capacity of 2200 tons daily in three machines, a 400-ton, an 800- and one 1000-ton; the last is the largest refrigeration unit ever built. It was designed by and constructed under the supervision of the Quincy Market Co.'s engineer, F. L. Fairbanks. This machine is shown in Fig. 1 and will be described later.

The street system has from five to six miles of piping, and for this and the seventeen large warehouses, there is a brine-pumping capacity of 50,000,000 gal. daily; this is used in hot weather. The brine-temperature drop between leaving and returning to the plant is maintained at 6 deg. F.

The temperature drop due to radiation in piping in this system is less than 1 deg. F., and the leakage loss through the system is a small percentage of the total pumped. Brine for this system is circulated by two large compound plunger pumps of the pot type and one turbine-driven centrifugal pump. Centrifugal pumps in the basement furnish brine to the warehouse system. The ammonia-head pressure is 180 lb., the back pressure on the warehouse system 40, and that on the street system 17. The brine is pumped into the system under 90-lb. pressure at the pumps.

The ammonia condensers are of the shell type, rated normally for 2500 tons daily, but they are often run at heavy overloads during the summer to keep down the investment and overhead charges on condenser equipment. Water from the harbor is used for cooling purposes and is first pumped through the ammonia condensers above the engine room; then it is dropped through the surface (steam) condensers before reaching the main outlet.

The boiler room has five 350-hp. stoker-fired water-tube and five 300-hp. hand-fired Scotch boilers using New River coal. The two main electric (alternating-current) generators are turbine driven and of a total rated capacity of 1000 kw. and 450 volts at 3600 r.p.m.

Boiler-Room Practice at the Plant

The boiler-room is the logical place to begin a study of the plant.

Perhaps because the management did not realize how rapidly its business would increase, is the reason for the now disadvantageous location and arrangement of the boilers and stack. The boiler room, or much of it, is built on a wharf or pier with the high-water level near the boiler-room floor. This makes ash hoppers and a conveyor under the furnaces practically impossible. Instead of the stack being located between and at one end of the two rows of boilers, it is at one extreme corner of the house. When there was only one row of boilers (the Scotch), this location was not bad, but now, with two rows, the breechings of the second row, or the water-tube, had to be carried to the ceiling, then across the boilers, where they connect with the header or main flue, which had to be placed directly over the old main flue for the Scotch boilers. Then these two mains connect with the trunk flue and economizer chamber. The work was costly and the construction productive of much friction of the gases.

Draft

The Scotch boilers are used comparatively little, for they cannot be as successfully and economically operated at high ratings as the water-tube, which are the long-tube Stirling. These water-tube boilers are provided with underfeed stokers, forced draft being furnished by one 140-in. fan, having duplicate engines. Two 140-in. fans supply induced draft, one at a time being used. They are in duplicate and each has its own engine, for they are more susceptible to service interruptions than the forced-draft fan, which does not receive the gases as do the former.

The furnaces have combustion-control appliances, indicating and recording gages and a CO_2 recorder, the average CO_2 being 10 per cent.

The Coal, Its Handling and Storage

New River coal is used, averaging about 14,900 B.t.u per lb., 4½ per cent. ash, 16 per cent. volatile and having an ash-fusing temperature of 2650 to 2675 deg. F. It is from the McAlpin and Slab Fork mines, and costs $3.65 per ton "alongside," i.e., in the boat alongside the bunker. The coal consumption increases continuously, and this year will be about 25,000 tons, or an average of 68.5 tons per day, the average for the summer months being much higher.

The new coal bunker, Fig. 2, built on a new wharf or pier, has a capacity of 5000 tons. It is of wood construction and rectangular in cross-section. The flat bottom has many gate outlets, but those down the center line will be mostly used. If a shortage occurs, the coal

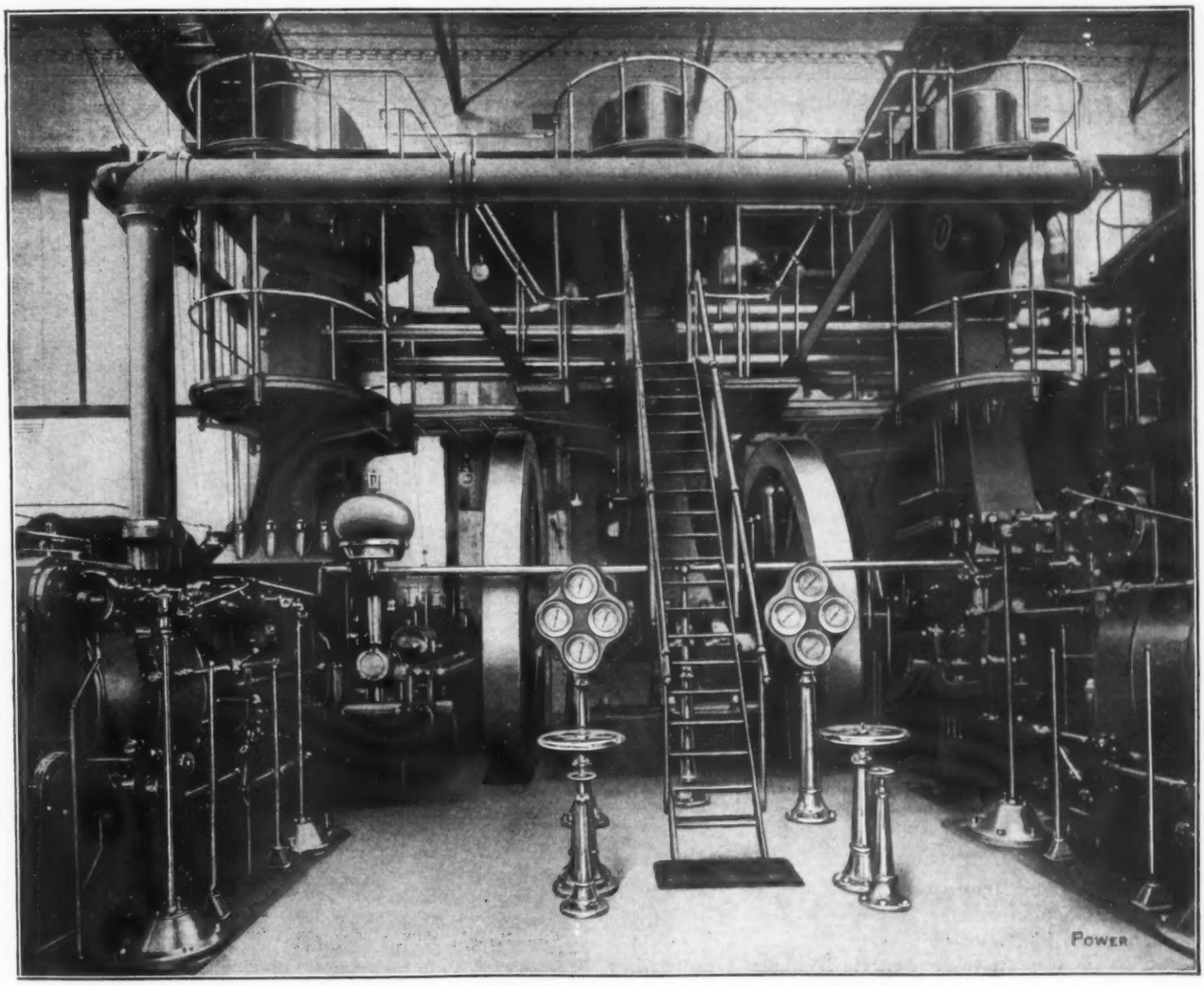


Fig. 1. The 1000-Ton Ammonia Compressor at Sargent's Wharf
This is the largest refrigeration machine ever built

stored along the sides (about 600 tons) can be drawn out easily. It will later be machine-conveyed into the boiler room and dumped into the stoker hoppers; now it is handled by car and by hand shoveling.

The annual coal consumption (25,000 tons) is a little more than that amount, for which it pays to install coal-hoisting and handling equipment. In Boston a stevedore with mast and gaff will unload coal for 25c. per ton, so that at the present consumption, the coal handling would

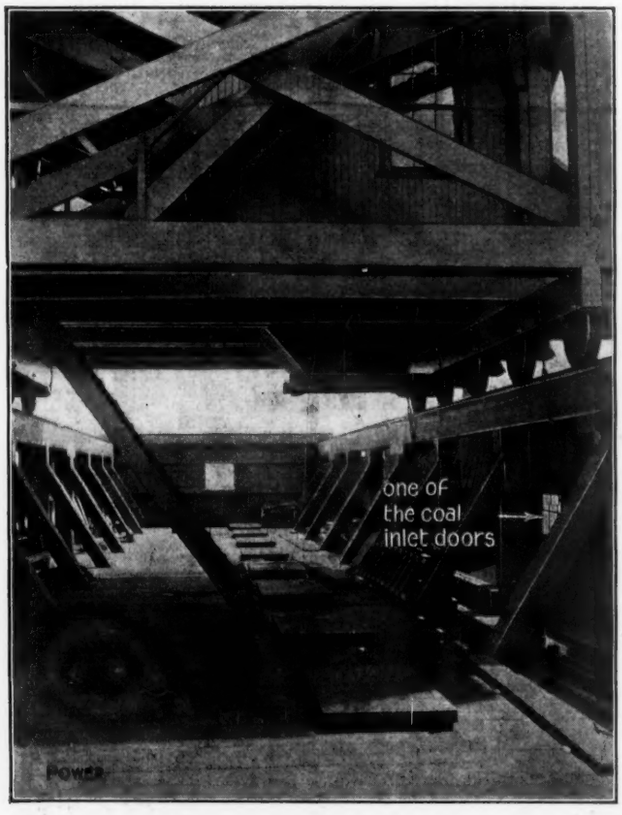


FIG. 2. TOP OF THE NEW COAL BUNKER

cost $6250 annually for stevedore service alone; this sum more than covers interest and other charges resulting from the investment. The hoisting equipment is electrical, everything except the motor being large enough for expected increase in the amount to be handled. As this increases and more coal must be hoisted in a unit of time, another motor of larger power will be used and the cycle of handling increased.

As the coal is dumped from the buckets, it runs over an inclined bar-grating, where all pieces under 2 in. pass through into the distributing hopper, which runs on a track, see Fig. 2 and 2a, over the bin. That which does not go through passes on to a crusher before getting into the hopper.

Fig. 2a is a view of the top of the bunker, looking toward the main building. To facilitate chuting coal into both the side doors and the hatchways, the chute telescopes, that part now in the hatchway being drawn up by a block and fall. With the chute in its present position it may be telescoped, and, by means of another block and fall, swung over to discharge coal into one of the side doors as shown by the dotted lines.

Many engineers favor steam instead of electrically driven hoisting equipment. With steam, the usual practice is to hire an engineer to run the hoist when unloading. Sometimes labor troubles arise with these men and shipments cannot be unloaded on time and, of course, demurrage charges go on in the meantime, besides, perhaps, emptying the bunkers of their supply. It was to avoid all possibility of these conditions being brought about that the electric equipment, which will be operated by one of the plant engineers, was installed. A foot switch is provided in the main circuit, so that should the operator fall or meet with any other accident, all steel-band solenoid-operated brakes in series with the switch will immediately bring the whole system to a stop.

BOILER OPERATION

The boilers are run at 200 to 250 per cent. rating for long periods. These ratings, it should be understood, last for days, and often weeks, so the practice is different from that in many central stations where such ratings apply only during the peaks. The duration of these high

FIG. 2a. THE CHUTE DELIVERS TO THE HATCHWAYS AND TO THE SIDE DOORS

ratings is one of the chief reasons for using a coal with such a high (2650 to 2675 deg. F.) ash-fusing temperature. With this high fusing point and low ash content (4½ per cent.) clinker troubles do not exist, and therefore it is not necessary to frequently take boilers off the line to clean and repair furnaces. If the fusing point were lower, say 2200 deg. F., this latter condition would, perhaps, exist and the cost of labor and maintenance in the boiler room would increase, although Mr. Fairbanks claims that this type of boiler can be taken off and put back on the line again for a cost of $2.50, including coal, labor, in fact all except repair costs.

When the load drops in winter, the boilers are cut out until those left in service have to run at 200 per cent. rating. The pressure carried is 160 lb.

Later, it is planned to handle the ashes with a steam ash ejector similar to systems aboard ship. At the company's Richmond St. plant, the services of one laborer in the boiler room have been eliminated by making the ashpit about 2½ ft. deeper than is usual with hand-fired boilers. A night's accumulation may be left in the pits for removal by the day force instead of keeping a man on nights chiefly for this purpose.

Combustion Control

It is well known that where fuel and load conditions remain uniform for long periods, it is possible to adjust the draft and thickness of fuel bed to get the best furnace efficiency. These conditions prevail at the Sargent's Wharf station. In addition to the recording and indicating draft gages, the combustion (draft) regulator and pyrometer for the flue gases, steam-flow meters are being put on the boiler fronts. Alongside and in cases to match, dial gages will be provided and calibrated to show the amount of opening of the back dampers. Adjustments will then be made for varying loads and these gages again calibrated to read in horsepower output, as indicated by the steam-flow meters, the aim being to give the firemen every convenience to assist in getting the best results. Almost identical control systems have been used with fair success in plants where the load and coal were not as uniform, therefore good results are expected at Sargent's Wharf. A double control is used, owing to the boilers using induced and forced draft.

The Feed-Water System

City water is used for feed and its control throughout is automatic. Besides the economizer, there is a primary heater into which the water enters at an average of 65 deg., passing at 100 deg. into the heater through which the hot ammonia gas passes on its way to the condensers. This heater conserves an appreciable part of the heat absorbed by the brine. The exhaust-steam heater taking steam from the auxiliaries passes water to the ammonia-gas heater also at about 175 deg. F. From the latter, at a higher temperature, the water passes into the economizer, to which the flue gases come at about 450 deg., the water leaving at about 275 deg. A recording thermometer is connected to the discharge line to the boilers. An average of 10 lb. of water is evaporated per pound of coal as fired.

The economizers are set differently to common practice in that the water does not enter the bottom header. Instead it enters the top one, which is blanked off with a partition between the second and third row of vertical tubes. As economizers are usually set, the cold water runs the length of the bottom header, a fraction of the total rising up through the tubes throughout the length of the economizer. Sometimes this gives rise to leaks all along the bottom header. But at Sargent's Wharf all the cool water must pass through two rows of tubes at right angles to the flow of gases, absorbing considerable heat, owing to the large temperature difference, before it may pass to the rest of the tubes. This way of passing the water, allowing for the size of the economizer, would seem to account for the very low gas exit temperature.

The Automatic Feed Control

A 6½ and 10 by 6-in. compound duplex plunger pump and a 6x10-in. induction-motor-driven triplex pump are now used for boiler-feed purposes. A spring-loaded regulating valve operated by the discharge pressure is connected in the steam line to the duplex pump, Fig. 3. To prevent too great pressure in the discharge from the triplex pump,

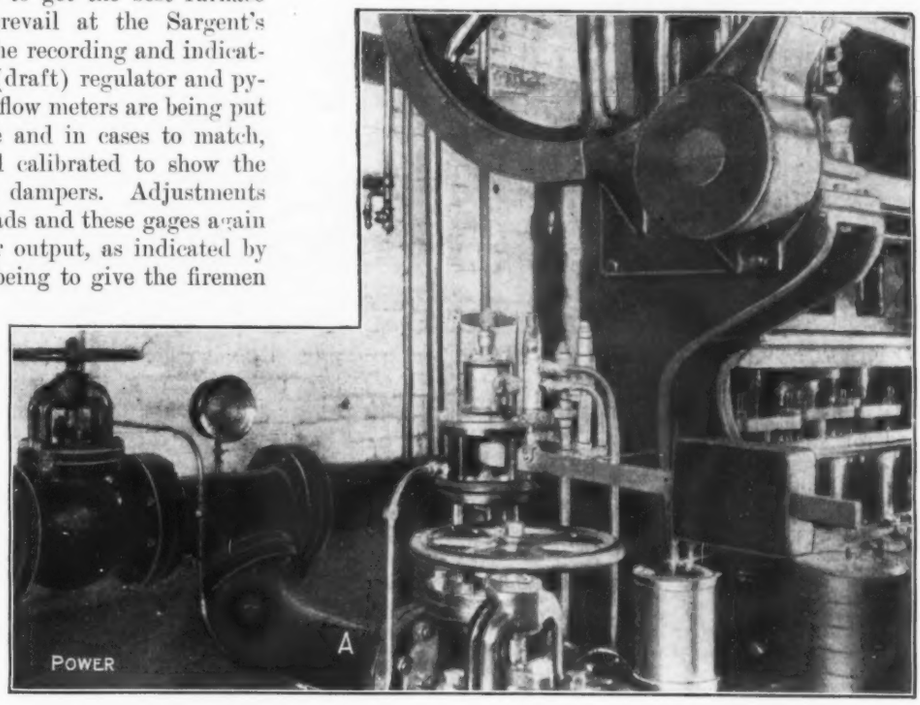


Fig. 3. Regulator on Shunt between Suction and Discharge of Motor-Driven Triplex Feed Pump

a weight-loaded regulator connected into a shunt *A* across the suction and discharge pipes allows the discharge water to flow back into the suction chamber. Two large injectors are provided for emergencies.

It is quite generally known that with fluctuating loads on the type of water-tube boiler used in this plant, the water level in one of the drums fluctuates widely, but this is not serious and occasions no alarm. The condition, however, is rather unfavorable to the use of automatic feed-water regulators, for while there may be sufficient water in the boiler, the circulation, when suddenly forced heavily, tends to "bank up" the water in one drum, causing the level in the other drums to drop. This makes an automatic regulator operate when not needed. At the Sargent's Wharf plant, the load is quite constant and the water level uniform, so that the "automatics" work most satisfactorily. All boilers have nonreturn valves with steel bodies and nickel-steel seats. Between each nonreturn valve and nonautomatic stop valve there is a relief drip to assure that the boilers will not accumulate condensate which might otherwise get by the valves.

About eight years ago, Mr. Fairbanks replaced all gate valves for steam and ammonia by globe valves, partly of his own design. This caused some adverse criticism at the time, but many now approve of the practice. In Europe, particularly in Germany, globe valves are used almost exclusively for superheated steam, as is becoming the practice here, for there is less distortion with globe than with gate valves. The disks are of conical frustum form, and they and the seats are of 90 per cent. nickel and 10 per cent. tin composition; the bodies are of steel.

Automatic Starting of Auxiliaries

Many engineers prefer to drive auxiliaries by motor, but hesitate because of fear of service interruptions due to failure of the electric supply to the motor. At the Sargent's Wharf station it is planned to use motor drive normally for all auxiliaries, such as feed pumps, draft fans, circulating pumps and exciters. As duplicate auxiliary units should always be installed, all duplicates will be turbine-driven, these units being automatically put into service when the motor-driven ones begin to stop.

Low-Voltage "Breaker" in Each Motor Circuit

There will be a low-voltage circuit-breaker in each motor circuit, which will open when the voltage in that circuit begins to fall. The throttle valve in the steam line to the turbine will open electrically when the breaker does and start the steam-driven auxiliary. Assuredly this is good practice. Take the case of exciter units, for example. With this arrangement of control, the turbine-driven unit could be made to cut in on the line supplying excitation current before the other "dying" unit had come to a standstill, thus enabling the main unit to immediately regain its partly lost load. The same is true for all the other auxiliaries. For the feed pumps, non-return valves would be connected into the discharge from each pump and in this way keep the line pressure off the idle one until it had built up its own pressure after starting.

The second article of the series will treat of the interesting features of the 1000-ton ammonia compressor in the Sargent's Wharf station.

Side-Feed Stokers*

By Osborn Monnett†

SYNOPSIS—Application of this stoker to return-tubular boilers and water-tube boilers of horizontal and vertical types. Instructions for starting, carrying the load and for banking fires.

Under this classification come stokers consisting of two inclined grates feeding from the side with a clinker bar at the bottom. It should be a fixed rule that no such stoker should be placed under a boiler without a full extension setting. This enables the heating surface to be worked to a maximum and gives the long flame travel required. To operate this stoker without smoke requires careful attention. Its construction is such that the fuel will easily slide down from the hoppers onto the grates, and when it does, smoke will be produced. The average fireman will poke this stoker to take care of fluctuations in the steam pressure, and invariably smoke is the result. Fluctuations in the steam pressure should be taken care of by the stoker engine. Poking should be limited and confined to the lower part of the stoker, where clinkers must sometimes be pulled out through the front door.

To insure a proper mixture of the gases when this stoker serves a return-tubular boiler, a two-span deflection arch is of the greatest value. Such a setting for a Model stoker is shown in Fig. 1. The combustion chamber should be excavated to the floor line and the deflection arch be set back far enough to make sure that the temperature will not become too high. The action of the arch is to interrupt the stratified flow of volatile matter that is distilled off at times when poking occurs or where an unusual amount of green coal slides into the furnace.

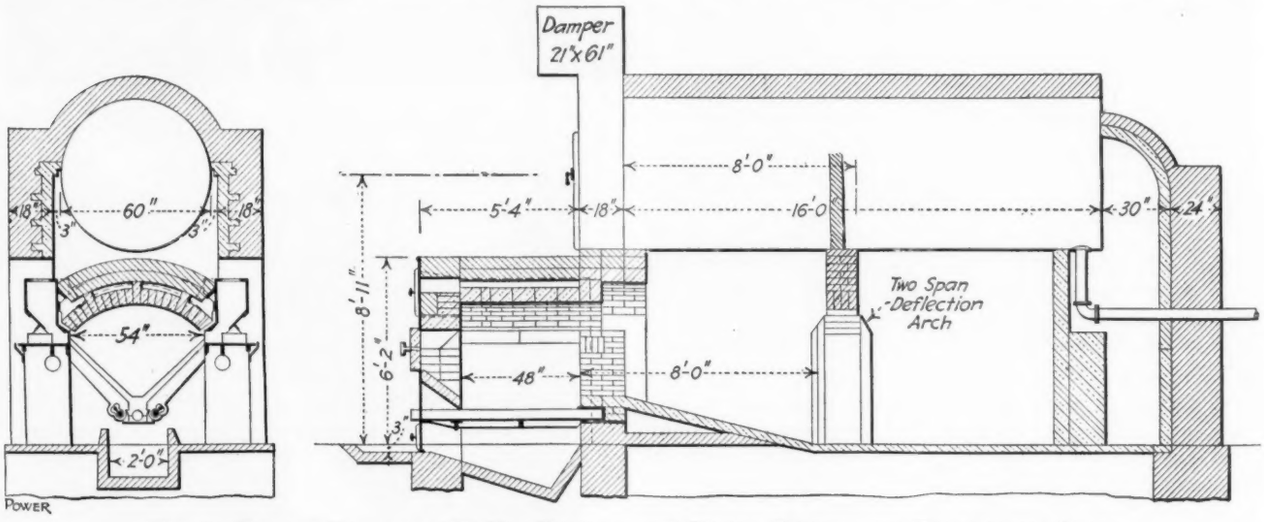


Fig. 1. Return-Tubular, 100-Hp. Boiler with Model Stoker and Deflection Arch

*Copyright, 1914, by Osborn Monnett.
†Smoke Inspector, City of Chicago.

This type of stoker can be applied easily to any type of horizontally baffled boiler or tile-roof furnace. Fig. 2 shows a Model stoker in connection with a Hawkes boiler and a two-span deflection arch. The furnace action is exactly the same as in the previous installation. The extension is 5 ft. 7 in. from the flue caps and there is plenty of area through the deflection arch to prevent bottling the

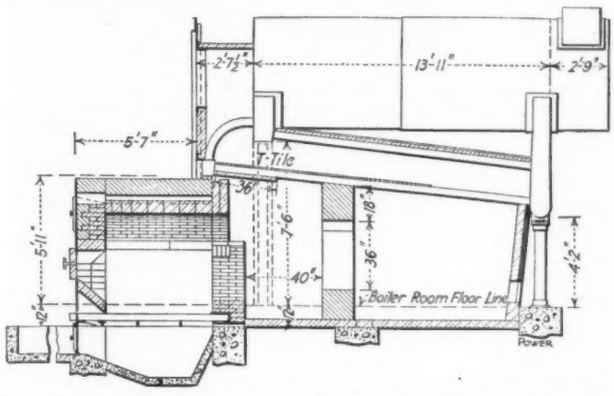


FIG. 2. MODEL STOKER AND DEFLECTION ARCH IN TWO SPANS SERVING 150-HP. HAWKES BOILER

heat. Besides, T-tile has been placed on the water tubes for a distance of 36 in. from the front header to cool off the furnace at this point to a good working temperature without affecting the smoke performance.

A satisfactory installation of Detroit stoker and Worthington water-tube boiler is shown in Fig. 3; the extension in this case is 10 ft. 9¼ in. from the boiler casing. The headroom to the top of the main drum is only 9 ft. from the floor line. The ashpit has been excavated 2 ft. 8 in. The results are a large capacity on low headroom with a long-flame travel and good smoke performance.

In applying the side-feed type of stoker to vertical water-tube boilers, it is not sufficient to set them close up against the heating surface. If this is done there will

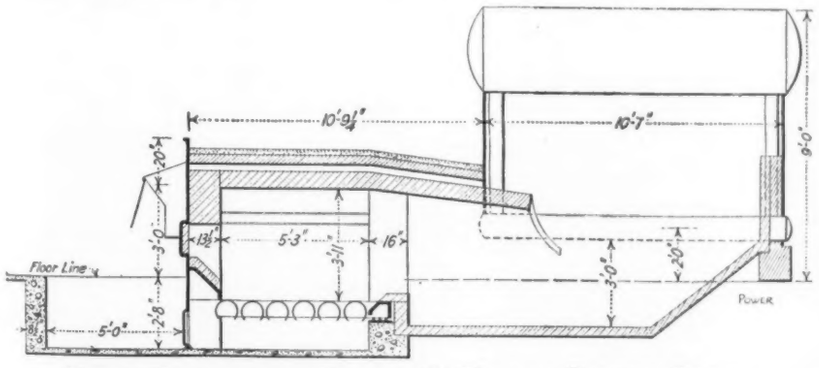


FIG. 3. WORTHINGTON BOILER, 150-HP., AND DETROIT STOKER

be times when the volatile matter passing off will make continuously No. 1 or No. 2 smoke on the Ringelmann chart. There should be a distance of at least 5 ft. between the end of the stoker arch and the nearest heating surface, as shown in Fig. 4. This space should be roofed by a step-up secondary arch, so that long-flame travel will be insured. Such an installation can be run satisfactorily from a smoke standpoint if the stoker is carefully handled.

Probably one of the most successful settings of this type of stoker that has come under the observation of the author is the installation shown in Fig. 5. It is a B. & W. boiler with Sewell baffle, equipped with a Murphy stoker and a deflection arch. The headroom under the boiler is 8 ft. 6 in. and the stoker is set full extension. A two-span deflection arch is set midway in the combustion chamber with ample area under the spring of the arches. One of the successful features of the furnace is the baring of the tubes at the front header for a distance of 4 ft., thus increasing the heat absorption and decreasing the temperature and brick maintenance. Then there is 4 ft. of box tile to the deflection arch, and T-tile is again used to the end of the first baffle. This unit runs satisfactorily from a smoke standpoint and is efficient. It was originally set without the deflection arch and with a complete baffle of box tile, but the performance since the alterations were made is much better than before.

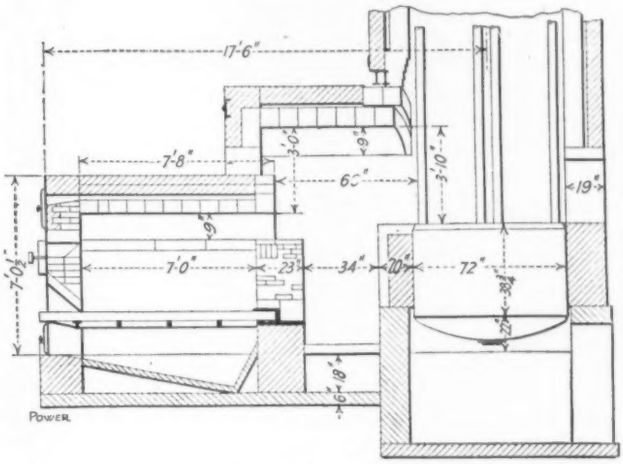


FIG. 4. WICKES BOILER OF 200-HP. CAPACITY AND MODEL STOKER

Another setting of a Murphy stoker with long-flame travel on a tile roof is shown in Fig. 6. The installation serves a Heine boiler and is a typical layout for horizontally baffled boilers. Under no circumstances should the furnace be set flush in such installations as they do not work out to advantage.

On a Stirling boiler anything less than full extension furnaces should not be considered. Fig. 7 shows the flame travel obtained on a Stirling boiler with a Murphy stoker set full extension. This is the only arrangement that can be expected to give a good account of itself.

OPERATION OF SIDE-FEED STOKERS

Starting Fires—Cover the clinker bar with wood to prevent the fuel from running into the ashpit. Fill up the hoppers and work in by hand enough coal to cover the grates. Place a small amount of clean wood kindling on top of the coal and ignite it. After the fuel is burning well, feed the coal onto the grates by hand until the arch is hot and the stoker can take its regular load; then it can be operated by the stoker engine. When the engine it attached, the clinker-bar connection should be left off until it is found necessary to work the clinker bar. When refuse accumulates sufficiently at the lower ends of the grates, connect the clinker bar to the operating mechanism, making sure beforehand that the bar will work freely and is not caught by fresh coal or clinker.

Carrying the Load—Always keep the hoppers full of coal. If this is not done, there will be a sliding of coal into the fire when the hoppers are replenished. This will cause smoke. Feed the coal continuously so that no large amount will be necessary at any one time. If this is done, the volatile matter passing off from the coal regularly fed will not be in excess of the capacity of the furnace to burn it. If the stoker is fed intermittently, there will be too much fresh coal in the furnace at one time and smoke will be made. Never poke the fire on the upper grates. In using the roust bar, be careful to see that no sliding of the coal occurs. If it becomes necessary to work the fire on the lower grates, handle the clinker carefully in order that there will be no avalanching of the coal from the top of the furnace. Regulate the thickness of the fire according to the draft and to the load. A thickness of from 3 to 8 in. is permissible. Fine coal or low draft calls for a thinner fire than coarser coal or good draft. Ordinary fluctuations in the load can be taken care of by regulating the ashpit doors. Do not close the damper on a heavy fire. It should never be closed to such an extent that there will be less than 0.15 in. draft over the fire while in operation, or smoke is likely to be made. This applies especially to plants having damper regulation.

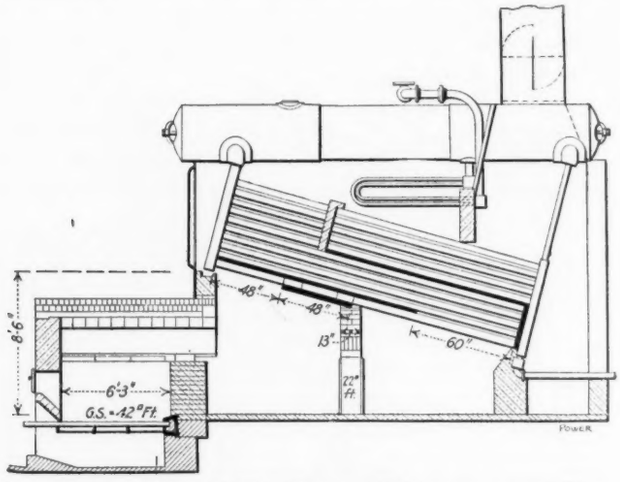


FIG. 5. B. & W. 200-HP. BOILER EQUIPPED WITH MURPHY STOKER AND TWO-SPAN DEFLECTION ARCH

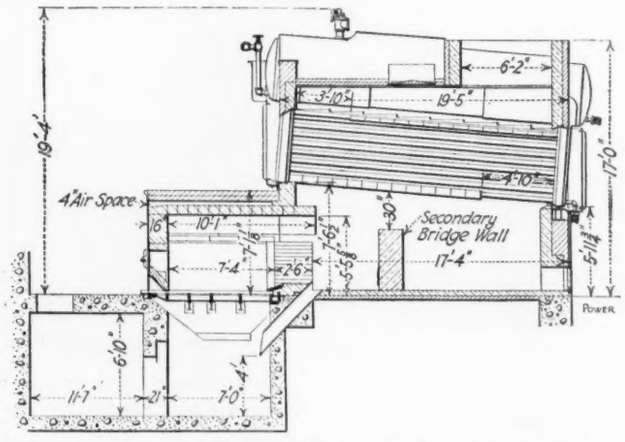


FIG. 6. TYPICAL HEINE BOILER SETTING WITH FULL EXTENSION MURPHY STOKER AND NO. 8 MIXING PIERS

Banking Fires—Run the side magazines empty. Pull the coked coal down to the bottom of the furnace and cover it with 25 or 30 scoops of fresh coal through the middle door. Leave the fire door open for a short time after the fire is banked and until the arch has cooled down, after which the ashpit doors and damper can be closed.

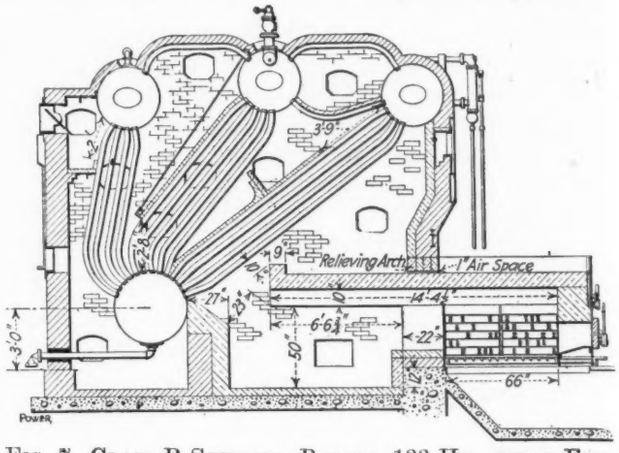


FIG. 7. CLASS P STIRLING BOILER, 133-HP., WITH FULL EXTENSION

In starting up after a shutdown, break up the bank with a hook and feed green coal carefully down the sides, with the damper partly open, until the fuel on both sides of the furnace is ignited. When the arch gets hot the damper can be opened wide and regular operation commenced.

Low-Voltage Direct-Current Generators

BY GORDON FOX

The low-voltage direct-current generator, which is used extensively for electroplating and electrochemical work, differs in many essentials from machines of higher voltages. The low voltage is accompanied by an extremely high current rating and the provisions for conducting and collecting these heavy currents are the distinguishing points of difference in design.

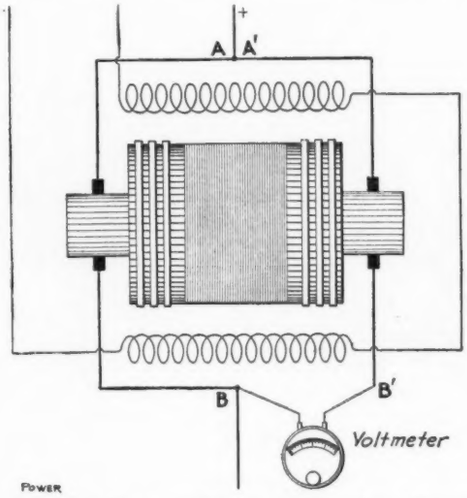


DIAGRAM OF DOUBLE-COMMUTATOR LOW-VOLTAGE GENERATOR

Armature conductors of generators of this type are almost always of the bar coil type, usually with a single-

turn coil and the armatures are lap-wound to give as many parallel paths as possible. The commutator segments are few and wide. Since the coils have but a single turn and the voltage is so low, there is little tendency toward sparking from armature induction effects, but to collect the heavy currents without undue heating of the commutator or brushes requires special provisions. Since the armature induction is low the use of copper gauze or composition brushes is allowable. Gauze brushes are perhaps the most common and the best for the majority of cases; copper leaf is sometimes used and a special brush utilizing copper gauze embedded in graphitic carbon sometimes finds application. If gauze or leaf brushes are used they should be set without too great angularity to the commutator, an angle of about 30 deg. being preferable. If possible, they should be staggered to prevent grooving of the commutator. The brush pressure must be fairly heavy but should be no more than is necessary to collect the current without burning the brush tips from high-contact resistance.

Many low-voltage machines of this type are provided with double-armature windings and two commutators to obtain more commutator surface and an even distribution of load. One commutator is mounted at each end of the armature. The two windings usually occupy the same slots but the coils face in opposite directions. This arrangement virtually provides two separate windings in parallel under the same field poles.

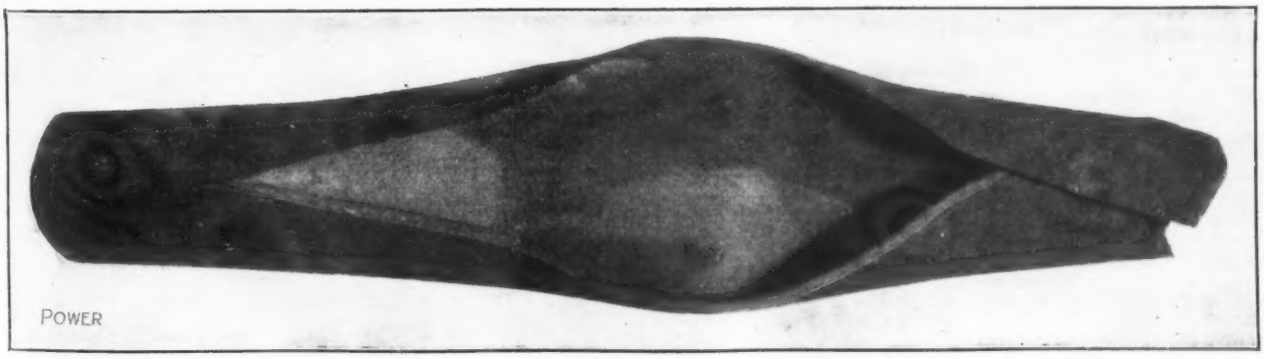
It is a familiar fact that the voltage of a generator and its load-voltage characteristics may be altered to some extent by shifting the brushes. Now consider the case of two separate armature windings in parallel, both under the same field poles; this corresponds to the double-ended, low-voltage machine. Since the rheostat adjustment affects both windings similarly, their voltages cannot be equalized through manipulation of the field strength. It follows that the relative brush positions upon the two commutators must be such that the same characteristics will be secured from both armature windings. To attain this end it is best to first properly space the brushes upon both commutators. Then run the machine, using only one commutator, setting the brushes on this end by shifting the rocker-arm until good commutation and minimum heating occur. Next, determine the leads of like polarity, such as A-A' and B-B', and connect together A and A'. Place a low-reading voltmeter between B and B'. Shift the rocker-arm on this second commutator until the voltmeter reads zero. The two armatures are now delivering the same voltages and have like relative positions. The leads B and B' can now be connected together with the knowledge that the two windings and commutators will properly share their loads.

It is evident that if the two armatures are connected in parallel without this procedure, it is likely that their voltages will be unequal and there will be local current flowing through the closed circuit of the two armature windings. This local current is a waste, which lowers the efficiency of the machine and increases its heating.

Where possible, it is desirable to provide separate excitation for the field coils of low-voltage generators. This excitation may be at 110 or 220 volts, whichever is available. Where these generators are self-exciting it is not infrequent that difficulty is experienced in getting them to build up, because the very low voltage generated by the action of the residual magnetism upon the one-turn coils is not sufficient to force an appreciable current through the shunt-field winding.

Openings Between Boiler and Engine Rooms—The openings around all pipes where they pass through the wall from the boiler room to the engine room should be thoroughly stopped up with asbestos or other suitable material. An engine room makes a poor appearance when smoke from the boiler room enters it through the space left between the pipes and the pipe thimbles and blackens the walls in streaks directly over these openings.

Burst Boiler Tube



Tube failures are the cause of more aggregate damage than any other one thing about the boiler plant. An explosion of a shell boiler is more spectacular, but there are not so many of them. This is the reproduction of a photograph of a recent example. It was a welded tube, but these seem to be no more liable to failure than the seamless variety; only, when they split in the weld, as this did, the split is apt to run for a greater length. Frequent inspection and the replacement of all tubes showing any tendency to bulge or to local distortion appear to be the best means so far devised for the prevention of such damage. The high rates of evaporation at present in use are responsible for much of the trouble. Scale or oil, which will cause no serious overheating of the metal when three pounds are evaporated per hour per square foot of heating surface, are very likely to make trouble when the evaporation goes up to six or ten.

Safety Rules for Operation of Electrical Equipment

The Bureau of Standards has recently issued, under the title, "Circular No. 49," a set of rules to be observed in the operation and maintenance of electrical equipment and lines. These rules have been compiled after a year's study of those of many of the large companies, aided by suggestions from commissions, company officials, workmen, etc. Space does not permit our giving the rules in full, but such items are included as should be particularly helpful to our readers. Complete copies of the report may be had from the Superintendent of Documents, Government Printing Office, Washington, D. C., for 15 cents each.

GENERAL

Attendance—A qualified employee shall be kept on duty where generators or rotary converters are operating, excepting small, low-voltage generators for telephone and similar work.

Two Workmen—There shall be at least two employees on any work near exposed live parts of equipment and lines above 750 volts in stations, in testing rooms, and on overhead lines, or above 150 volts from earth in underground construction where it is necessary to approach such parts within the distances later specified.

Diagrams for Chief Operator—Diagrams showing plainly the arrangement and location of all parts of the electrical equipment and lines must be maintained on file with the chief operator.

Accident Reports—Report blanks shall be issued to each employee and their use required for reporting to the employer each personal injury on or about the equipment and lines. These shall contain at least the following information and shall be filled out at the time of the accident:

(a) Date, time and locality.

(b) Age and nationality, and does person speak English?

(c) Regular occupation, occupation at time of accident and years of such occupation.

(d) Extent of injury.

(e) How did accident occur?

(f) Was original cause of injury electrical or otherwise?

(g) What defects of construction, protection, illumination or carelessness were concerned in the accident?

(h) Were other employees present?

(i) What first aid was given, how soon after the injury and how long continued?

(j) Suggested improvements for preventing similar accidents.

(k) Voltage.

Treat Everything as Alive—Electrical lines and equipment should always be considered as alive unless positively known to be dead.

Safety Appliances—Employees at work on or near live parts should use the safety devices and special tools provided, first making sure that they are suitable and in good condition. Safety devices may get out of order or be unsuited to the work in hand.

Duties of Chief Operator—The chief operator shall keep a log-book showing all changes in the conditions of operation, including the starting and stopping of electrical supply equipment, the location and nature of work started or completed, the name of each foreman locally in charge of work and all unusual occurrences or accidents.

He shall sign the log-book when assuming duty and before being relieved.

He shall keep within sight an operating diagram or equivalent device indicating whether electrical supply circuits are open or closed and where the work is being done.

It shall also be his duty to enforce the safety rules and to permit only authorized persons to approach equipment or lines.

Control of Electrical Supply Circuits—Employees shall secure special authorization from the chief operator before closing circuits or starting equipment, and before opening or stopping them.

Exceptions—In emergencies, to protect life and property, any employee may open circuits and stop moving equipment without special authorization if he is sure that his action will promote safety, but the chief operator must be notified immediately of his action with the reasons therefor.

Authorization for Work—Special authorization from the chief operator shall be secured before work is begun on or about equipment or lines and a report shall be made to him when such work ceases. When there is more than one workman at any place the foreman locally in charge shall secure the authorization.

Reporting Clear—No instructions for making alive equipment or lines which have been killed to protect workmen shall be issued by the chief operator until all workmen have reported clear. When there is more than one workman at a location, the foreman locally in charge of such dead equipment or lines shall report clear for all his workmen only after all have reported clear to him. If there is more than one gang, each foreman shall separately report clear to the chief operator.

Maintaining Service—When circuits above 750 volts automatically open immediately after each of three consecutive closings, they shall be disconnected until they have been found clear by proper test.

When circuits at which men are known to be at work are opened automatically, they shall be disconnected until the chief operator has ascertained that the workmen are safe and until he has given proper authorization.

When circuits feeding supply lines become accidentally grounded, by indication of ground detectors at stations, they shall be opened, and if upon trial closing the ground still exists, the lines shall be disconnected until they have been found clear by proper tests.

Tagging Electrical Supply Circuits—Before work is done on or about any equipment or lines, either dead or alive, the chief operator shall have "Men at Work" tags attached at all points where such equipment or lines can be manually controlled to plainly identify them.

Protecting Workmen—When lines or equipment are to be disconnected from any source of electrical energy for the protection of workmen, the operator must first open the manual cutouts designed for operation under load and then the air-break disconnectors.

Touching Live Parts—No employee shall touch two parts of different potentials at the same time.

Employees shall not touch any exposed ungrounded live parts at any voltage unless insulated from floors and other conducting surfaces by approved insulating covers, mats or platforms. If permanent devices are not provided, portable ones shall be used.

Extra High Potentials—No employee shall come within or bring any conducting object within the distances named below from any exposed ungrounded live part at or above the voltage specified:

Operating Voltage	Distance, Feet
7,500	2
27,000	3
47,000	4
70,000	6

In dry locations these distances may be reduced, if approved insulating or grounded metal barrier devices are placed between the person and such part.

If the part is being worked on directly, the tools or other mechanical appliances used must provide the full distance of insulating material unless protective barriers are also used between the person and the live part.

High Potentials—No employee shall come within or bring any conducting object within 1 ft. of any exposed ungrounded live part whose potential exceeds 150 volts in underground construction, or 750 volts in stations, testing rooms or overhead construction.

In dry locations, this distance may be reduced if grounded metal devices are placed between the person and the part or object. This distance may also be reduced if approved insulating barriers are placed between the person and ground as well as between the person and all other conducting surfaces which he could accidentally touch at the same time.

Where greater space cannot be secured by use of the special insulating tools and appliances furnished or as an additional safeguard, properly tested insulating gloves and sleeves may serve as portable insulating devices between the person and live parts below 7500 volts.

Wire Insulation—Employees must not place dependence for their safety on the insulating covering of wires.

Work from Below—Employees must not work from above on exposed live parts of equipment or lines when work can be done from below. Moreover, they should avoid working on equipment or lines from any position by reason of which

a shock or slip will tend to bring the body toward exposed live parts.

Opening and Closing Switches—No employee shall open a cutout not designed for interrupting a loaded circuit unless the circuit has first been interrupted at a proper cutout.

Manual cutouts shall always be opened or closed by a single unhesitating motion and, if possible, with one hand. All cutouts shall be handled only by means of the insulating handles provided.

Loose Wires—Loose conductors should never be brought near exposed live parts except those to which they are to be immediately connected.

Handling Connecting Wires—In connecting dead equipment or lines to a live circuit by means of a connecting wire or device, employees shall first apply the wire to the dead part before attaching it to the circuit. When disconnecting, the live end shall be removed first.

Never Open Series Circuits—Series circuits or secondaries of current transformers shall never be opened. A jumper must always be connected across any device inserted in such a circuit before working on the device.

Applying Grounds—In applying a grounding device to normally live parts, the device must be grounded before bringing it near the parts, and must be removed from the live parts before removing it from the ground connection.

KILLING SUPPLY EQUIPMENT AND LINES

Ascertain if Parts Are Dead—No employee shall approach any exposed ungrounded part, normally alive, within the distances specified, except as allowed in these rules, unless he has first assured himself of his own safety and that of those working under his direction by taking the following precautionary measures in the order given:

Foreman's Request—The foreman locally in charge of the work shall request permission from the chief operator to have the particular section killed.

The chief operator shall at his discretion advise the foreman that the particular section will be killed and that instructions will be given the foreman when he can safely proceed.

Opening Disconnectors and Tagging—The chief operator shall direct the proper persons to open all disconnectors, including suitable air-break cutouts, through which electrical energy may be supplied to the particular section to be killed, and shall require each person to lock each disconnector open and to tag the same, and each tag shall state in large letters "Men at Work."

Protective Grounds—When all the disconnectors designated have been opened, locked and tagged, the chief operator shall require each person operating them to make protective grounds upon the section which is to be killed and to report when such grounds are in place.

Permission to Work—Upon receipt of information from all persons operating disconnectors that protective grounds are in place, the chief operator may advise the foreman that he may proceed to work, considering the specified lines or equipment dead.

Foreman's Record and Grounds—The foreman shall record on a card the time the lines or equipment are reported dead, the particular lines or equipment specified, the name of the chief operator and sign his own name. He shall then immediately proceed (except in underground systems) to make his own protective ground on the disconnected section of the equipment or lines in the manner specified.

Grounds shall be made on the dead equipment or lines between the particular point at which work is to be done, and each disconnector which has been opened by the above procedure for his protection.

Proceed with Work—After the section has been killed, the foreman and those under his direction may proceed with work on or about the dead section.

Reporting Clear—Each foreman, upon completion of his work and after assuring himself that all the men under his direction are in safe positions, shall remove his protective grounds and shall report to the chief operator that all tags protecting him may be removed and record the time of such report on his record card.

Reporting Removal of Tags—The removal of any tag from any disconnector shall be reported immediately to the chief operator by the person removing it.

Upon the removal of any tag there shall be added to its record the name of the chief operator, the time of removal, who requested it and the signature of the person removing the tag. The tag shall then be filed with the chief operator.

Restoring Service—Only after all protecting tags have been removed by the above procedure from all disconnectors shall the chief operator, at his discretion, direct the removal of locks or blocks and of protective grounds and the closing of any or all disconnectors.

Care About Machines—Do not allow oil cans, tools and wiping cloths to catch in moving parts of machinery. In passing any machine in operation, be careful not to touch it or allow tools or other pieces of metal to touch the machine or its connections. Do not use iron or tin oil cans near field magnets. Use only oilers and wipers with insulated handles around commutators, switches and other electrical equipment.

Loose Clothing—Avoid loose clothing about moving parts of machinery and do not wear shoes that slip easily on the floors about live or moving parts.

Killing Parts Worked On—Do not work on any normally live or moving part, feeling assured that it is not alive or will not move, unless you have first protected yourself against danger by having the live or moving part killed.

Open Flames—Do not smoke or bring open-flame devices into storage-battery rooms.

Report Defects—Promptly report any broken or unsafe tools, defective safety appliances, apparatus or any dangerous condition of equipment or surroundings.

SWITCHBOARD OPERATION

Care about Live Parts—Do not work on or near exposed live parts unless authorized to do so, and then strictly observe the rules laid down for such procedure.

When working near fuses and circuit-breakers be careful to avoid injury from their operation. If the hands are exposed to flashes, wear insulating gloves.

When working on one section of a switchboard or in one compartment, mark it conspicuously and place barriers to prevent accidental contact with other sections or entrance into other compartments.

Handling Switches and Fuses—Do not open manual cutouts which are not designed for opening loaded circuits unless the circuit has first been opened at a proper cutout.

When operating manual cutouts, keep the body as distant and as far below as possible and use only one hand.

In handling fuses or switches, use only the insulating handles or the special rods or tongs provided. In handling voltage transformer fuses, always stand on an insulting mat or platform.

Never replace nor remove link fuses from live terminals.

When cable plug connectors are used, do not allow one end to remain loose while the other is connected to a live terminal.

Protecting Others—Do not report lines or equipment dead for other men to work on until the lines or equipment have been cut out by air-break manual cutouts, protective grounds have been applied to the parts so cut off and "Men at Work" tags have been attached to the cutouts.

Also, in reporting, identify the parts by position, letter or number as well as by description.

Report to Chief Operator—Report to the chief operator any unusual conditions of load, the opening of any automatic cutout and the indication of any ground on a normally ungrounded outgoing circuit.

Closing Circuits—Do not again close circuits above 750 volts which have automatically opened immediately after each of three consecutive closings within 10 min. without special instructions from the chief operator.

Do not again close any circuit opened by automatic cutouts if persons are known to be working on the circuit.

Handling Switchboard Equipment—All metal parts of equipment on switchboards shall be handled as if operating at the highest voltage to which any part of the equipment on the same switchboard panel is subject, unless the parts are known by test or otherwise to be free from such voltage.

Accidental Grounds—When an accidental ground is indicated on a normally ungrounded circuit immediately open the circuit. If upon a trial closing, it is found that the ground still exists, open again, and do not again close without special instructions from the chief operator.

Steam in Gas Producers—As to the amount of steam required to operate gas producers, there is but little authentic data and no general rule can be given. The character of the coal used has much to do with this question as more steam is needed for coal which clinkers badly than for that which does not. The size of the gas mains and the capacity at which the producers are worked are also determining factors. In a general way, however, it may be stated that under ordinary conditions not more than from 2 to 5 per cent. of the heat units in the coal are needed to generate sufficient steam. As some of this heat is returned to the producer, the actual loss is less. If possible, the steam used should be superheated to prevent condensation and moisture for, if wet steam is introduced, a chilling action might result from reëvaporation. It has also been found that a hot blast gives better results than a cold one. The pressure at which a producer is blown usually ranges from 30 to 40 lb. per sq.in.

Transmitting Power by Rope Drives

By Henry D. Jackson

SYNOPSIS—The advantages and disadvantages of rope drives; the relative merits of the American and English systems; a comparison of cotton rope with hemp.

Rope drives have a number of advantages over belts and, probably what is equally important, a number of disadvantages. The primary advantages are:

1. The distance through which power can be economically and satisfactorily transmitted is much greater with rope drive than with belts. Also, power can be economically transmitted over very short distances with ropes.

The disadvantages of rope drives are:

1. More or less skill is required to properly adjust and install the ropes.

2. Necessity for the ropes being particularly adapted to the character of the drive.

3. Large diameter of the pulleys, special pulleys being required, which in the case of accidents, may result in long delays for repairs.

4. Necessity for avoiding heavy overloads in order to prevent rapid deterioration of the drive.

The most prevalent trouble is deterioration, owing to overloaded conditions and to the use of too small pulleys. Manufacturers are insistent that the minimum diameter of the sheaves should be at least thirty-six times the diameter of hemp rope and thirty times the diameter for cotton, but there are many conditions in factories where this practice is impossible, and pulleys for hemp rope are used down to thirty times the diameter. This is unwise and has in many instances brought rope drives into disrepute. Where the pulleys are properly designed for the diameter of the rope the drives have given excellent service.

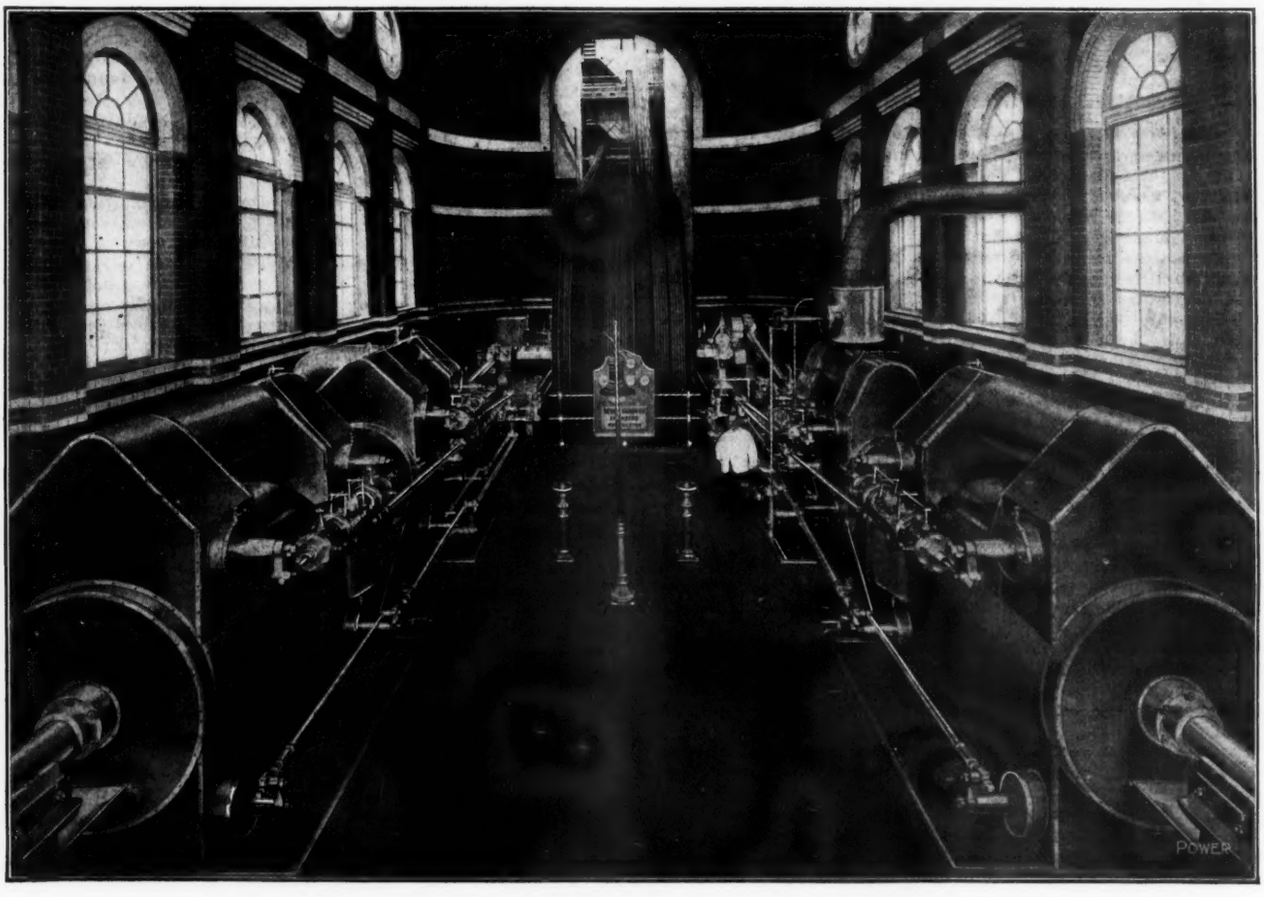


Fig. 1. Showing Typical English Engine Room and Rope Tower

2. The amount of power that can be transmitted by rope is limited only by the capacity of the shaft and the space between the bearings, as the number of ropes can be increased to meet the power requirements. This is quite different from belts as it is not easy nor economical to increase the capacity by an increased number of belts.

3. Economy in installation cost and, so long as the drive is properly installed and maintained, low maintenance cost.

4. Less space is required for a given capacity of drive.

5. Steadiness and quietness of the drive.

6. Absence of slip or creep and to a large extent the elimination of static electricity.

7. The ease with which power can be transmitted to shafts at an angle to the driving shaft as well as ease of transmission from floor to floor.

Unquestionably, the use of high-speed machinery, particularly motors, has brought about this condition. However, care should always be taken in the installation of rope drives to make the total yearly cost as low as possible. Low first cost does not always mean low yearly

cost, and slow-speed motors with larger pulleys are probably more effective in reducing the total yearly cost from this standpoint than the use of high-speed motors.

There are two distinct types of rope drive, the English and the American. The former consists of a number of single loops, each made endless by splicing or by means of fasteners; the writer does not advise these. Each rope is absolutely independent of any other and carries its proportion of the load. If one rope breaks, the others

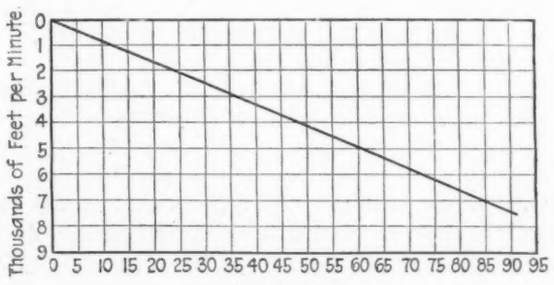


FIG. 2

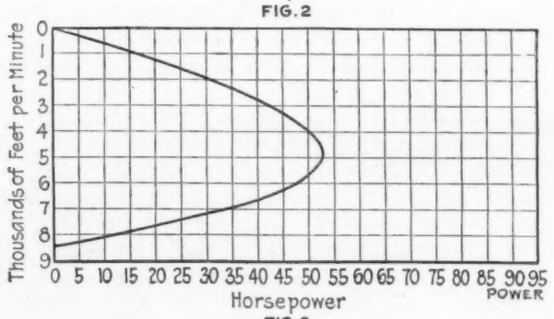


FIG. 3

FIG. 2. TRANSMITTING CAPACITY OF COTTON ROPE
FIG. 3. TRANSMITTING CAPACITY OF HEMP ROPE

can continue in service at a slightly reduced capacity unless the owner is willing to take the chance of overloading and, therefore, deteriorating the rope during the period that one is missing. In drives of this character it is wise to design for considerable overload so as to meet this condition without straining any of the ropes.

The American, or continuous-wrap, system consists of a single rope running from the driving shaft to one or more driven shafts, returning to the driving shaft, and repeating the operation as many times as may be required to distribute the necessary power. The slack is carried to a tension pulley on a traveler and thence to the driving sheave. This system gives good results in many cases and has many advocates; whether it is an improvement over the English system depends upon the point of view of the person using it. Its principal weakness is that a break at any point completely disables the drive. It is complicated to install and is equally so to repair, requiring expert service and taking a long time. The drive is not particularly uniform in its results, owing to the slack traveling from place to place throughout the drive when the load varies on the different shafts, and upon suddenly reaching the tension carriage, causes it to surge and jump.

In general, the main drives from the engine to the main shafting are by the English system. The vertical drives from one shaft to another, if the power is comparatively small, are by the American system. There are plants, however, in which either system is used entirely.

For driving purposes two kinds of rope are employed, hemp, or manila, and cotton rope. In America cotton rope is little used for main-shaft drive. It is used to a limited extent on certain machinery, but in these cases it is almost invariably purchased abroad as no good cotton transmission rope seems to be made in this country.

The characteristics of hemp rope are given in the curve, Fig. 3, from which it will be noted that the economical limit of speed is approximately 5000 ft. per min. Above this speed centrifugal force acts to throw the rope out of contact with the pulleys and the driving power drops off rapidly. The curve is figured upon the basis of the maximum allowable tension being 200 times the square of the diameter of the rope. This tension is on the driving side; that on the slack side will depend on the centrifugal force of the rope and such tension as may be necessary to keep it from slipping.

Manila rope is made from the best grade of manila fiber, which has a high tensile strength but is very weak across the grain and will not stand excessive bending. The fiber is also harsh or stiff, and tends to cut when made in the form of rope and bent, so that the fibers must not

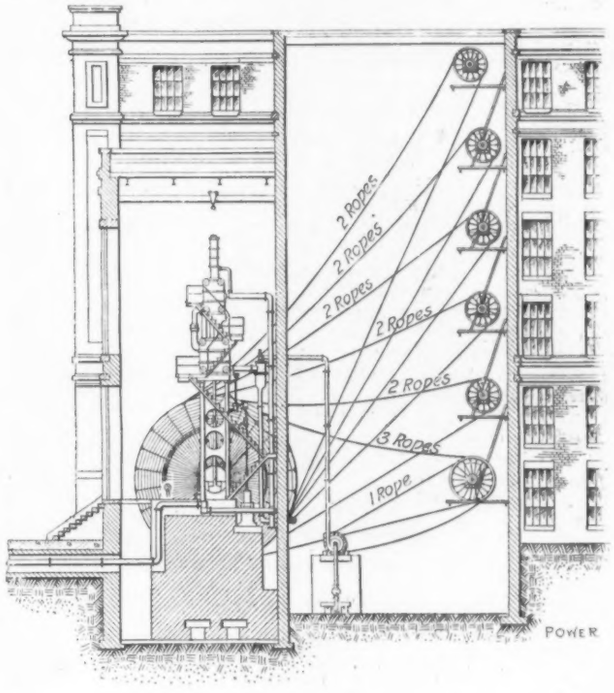


FIG. 4. HIGH-SPEED ENGINE DRIVING SEVERAL LINE-SHAFTS

be put under excessive cross-strain nor bent to too short a radius. To avoid the troubles incident to this bending, such as local wear or abrasion, the ropes are frequently lubricated. Even under these conditions, the life of manila rope, when operated at or near full load, seldom exceeds ten years. Compared to belts this means that the initial cost of the rope drive must be considerably less to warrant its installation.

The early hemp and cotton ropes were three-strand. It was found, however, that three-strand ropes of hemp, except for small drives, did not give as good service as four-strand, particularly those having a central core; also, four-strand rope is more nearly cylindrical and is more likely to assume that rolling motion which is instrumental in lengthening its life.

In direct contradiction to the statements of the Amer-

ican rope manufacturers are the statements of foreign manufacturers. The former claim that the most satisfactory material for rope is manila fiber, while the latter say that cotton is the most satisfactory. The writer has no data as to the actual life of American rope drives, but taking the figures given by the manufacturers, it is fair to assume that the ropes do not last much beyond the ten-

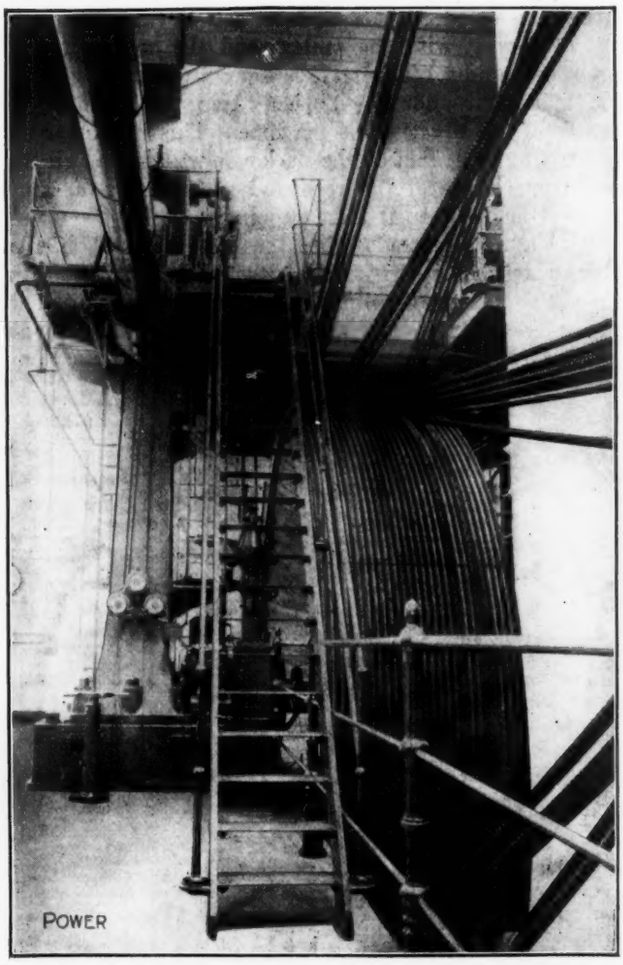


FIG. 5. HIGH-SPEED ENGINE WITH 1⅝-IN. ROPES TRANSMITTING 95 HP. PER ROPE; RIM VELOCITY 7033 FT. PER MIN.

year limit. Comparing these figures with the English cotton rope, one finds among the latter a number of drives that have lasted over thirty years. It is true, however, that the English rope costs from one and one-half to twice that of American rope.

According to some American manufacturers, cotton rope cannot transmit as much power as a manila rope of the same size. From their catalogs, a 2-in. manila rope at a speed of 5000 ft. per min. will transmit approximately 51 hp. According to the English rule, a 2-in. cotton rope will transmit approximately 65 hp.; this shows that the tension which may be put upon a cotton rope is greater than that for manila. This is not because a cotton rope is as strong or stronger, for the reverse is true, but, owing to the structure of the hemp and the harsh character of the fibers, it cannot be operated at high tension because the bending under these conditions would tend to make one fiber cut into another.

It is also true that at this speed centrifugal force plays an important part when manila rope is used. Cotton has no such limit as the fibers are soft and mat one upon another without injury; also, with cotton the grooves are so shaped as to make the ropes wedge and centrifugal force is practically eliminated. This makes it possible to exceed 5000 ft. per min.; in fact, one English manufacturer recommends speeds as high as 7000 ft. per min. Moreover, the pulley diameters in this case are thirty times that of the rope, whereas for equivalent service the American manufacturers limit the pulley to forty diameters. This in itself will make considerable difference in cost in favor of the cotton rope.

The cotton rope as recommended is preferably three-strand, permitting the wedging action which tends to eliminate centrifugal force. Fig. 2 shows the capacities recommended for a 2-in. cotton rope at different speeds with the pulley diameter thirty times that of the rope. This curve is worth comparing with that in Fig. 3.

Ordinarily, for vertical drives the continuous system would be used in this country, owing to the difficulty of obtaining a proper wrap on the lower pulley with manila rope. It has been found abroad, however, that with cotton rope no such system is required, the ordinary English

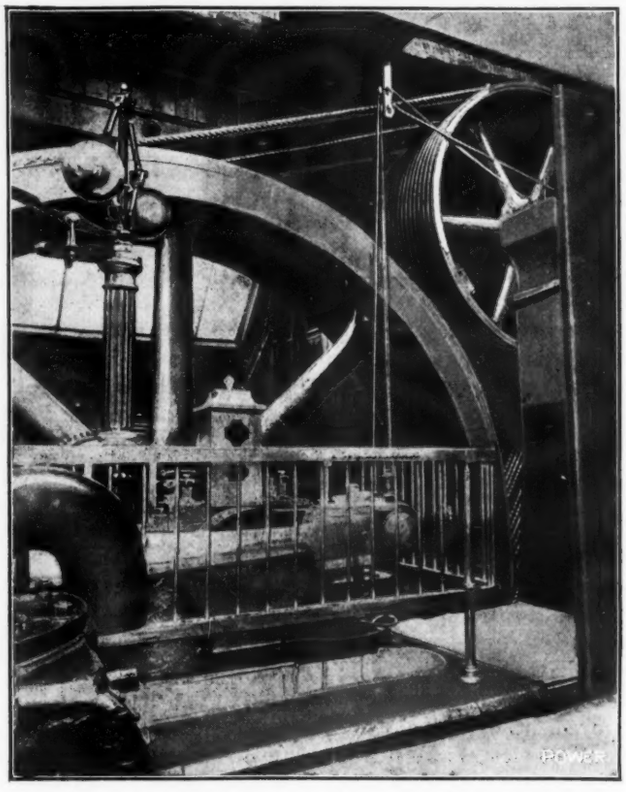


FIG. 6. ROPE DRIVE WITH SHORT CENTERS

wrap being used, and no difficulty is experienced without the use of idlers. This naturally improves the drive by a reduction in friction as well as a decided reduction in the amount of bending.

The theory has been advanced by the American rope manufacturers that cotton rope is not adapted to service in this country owing to climatic conditions. Two mills here, in widely differing localities, refute this. One has been in operation for over ten years without a single rope being touched; the other, for over twenty years without any change having been made on the ropes.

Certain it is that rope drives have their place and, in spite of the life of the hemp rope being limited, it is largely used. What would be the result if American manufacturers would produce rope costing double that of the present hemp but having a life several times as great and a capacity 30 to 75 per cent. greater? Would not rope drives replace belts in many instances, and would there not be good reason to believe that in many cases where electric drives have been used, rope drives would be installed with greatly reduced first cost and a probable reduction in the operating cost?

The generally accepted opinion here is that American cotton is not adapted to rope drives and, therefore, that it would be necessary to purchase the more expensive Egyptian cotton. The drives mentioned refute this as the English manufacturer giving this information stated that the ropes used were made from a good quality of American yarn and that American yarn gives quite as good service as the Egyptian.

The reason for American yarn being more effective than the Egyptian is that the fiber is not as silky and, therefore, has the necessary resilience. While American fiber is not as strong as the Egyptian, its elasticity saves it under strain and on the whole makes it better for driving purposes.

There is no reasonable limit to the distance power can be transmitted with ropes, either long or short. With suitably arranged idlers, the drives can be carried 200 ft. or more in alleys, or in the open up to 400 or 500 ft. if there is vertical distance enough to take care of the sag and the idlers are properly distributed. For a minimum distance there are instances where rope drives have replaced gears with no change of centers. The drive illustrated in Fig. 6 has operated satisfactorily for a number of years. It is more efficient than gears and eliminates the noise incident to the latter. Of course in a case like this due consideration must be given to the arc of contact on the smaller pulley and the number as well as the size of ropes. This drive would have been impossible with belts, owing to the ratio of speeds as well as the short centers, because the necessary surface could not have been obtained without excessive pulley width. The slip would have been enormous and the belt tension so great as to wear out the belt in a short time. With cotton ropes, owing to the grip of the rope in the grooves, no difficulty has been experienced.

The initial cost of rope drives is less than that of belts, not due to a reduction in the cost of the pulleys, for these are practically equal, but because the cost of rope is much less than that of belts.

The space required for an installation is less with rope than with belts. In a drive of approximately 1000 hp. the ratio of rim widths is 102 for belts to 58 for rope, and for a drive of 250 hp. the ratio is 28 to 17. This would naturally have considerable bearing on the width of a belt tower or on the amount of space taken from a room for driving purposes.

With belts there is a decided difference in rim speed between the driven and driving pulleys, owing, first, to the creep, which is from ½ to 1 per cent. of the speed of the belt and, second, to the slip, which is independent of the creep and may vary from 3 to 5 per cent. in a good drive; even greater in one poorly laid out. With cotton rope creep does not exist because of its elasticity. The rope may stretch on the high-tension side to a certain extent, but its spring or elasticity makes it contract again upon reaching the loose side; if the rope wedges to a certain extent, creep is practically eliminated. Slip cannot exist without rapid deterioration of the rope, so that the speeds of the driving and driven shafts hold a constant ratio. This feature is important as the speed of the machinery varies with the load with belts and thus the production varies, whereas with ropes the speed of the machinery remains constant and the production is constant.

How Much Is Exhaust Steam Worth?

By G. D. Crain, Jr.

This query is suggested by a recent discussion, when a flour miller and a prospective ice manufacturer considered the use of the mill's exhaust steam. The iceman was going to install a machine operating with exhaust steam, and if he could "hook up" with the mill it would save him from buying a boiler.

It looked as though the steam ought to be sold cheap, as what the miller would get out of it would be "velvet." But the price would naturally be affected by the value of the steam to the purchaser, and its value would be indicated, presumably, by the cost of making live steam since that would have to be produced unless the exhaust could be provided. The miller had the steam and the ice manufacturer wanted it, and the balance between the two was so nicely adjusted that the price as finally determined was just about the difference between zero, the previous value of the steam to the miller, and 50 cents, which was the estimated cost of fuel entering into the production of one ton of ice.

The result was that a contract covering a period of years was entered into between the miller and the ice concern, giving the former 25 cents for each ton of ice produced with his steam. The contract was made for a long term to protect the miller and insure him a satisfactory revenue; to protect the iceman and prevent the miller from putting in a machine of his own. Both sides were perfectly satisfied and believed that the exhaust steam was sold at a fair price.

If one were selling exhaust steam for heating, the price would probably be less than if used for manufacturing purposes. For example, the writer knows of a knitting mill operated by motors which needs steam for dyeing, and for this purpose it is valuable. This mill is the neighbor of a woodworking plant, not using its exhaust steam, and the knitter is wondering whether it would be worth while to negotiate with the head of the other factory for the steam now being wasted. He does not, for one reason, because he is afraid the woodworker may suddenly decide that he needs the steam for drying purposes and would cut it off. While a contract would cover this, it might not prevent friction.

A good way to determine the value of exhaust steam is to consider that often live steam is used when exhaust would serve the purpose. To that extent, exhaust steam is worth as much as live. The value depends on the use to which it is to be put, and the maximum market price, apart from the abstract matter of value, is limited by the cost of producing live steam to do the work. Undoubtedly there are many plants now throwing away their exhaust that might find or make a market for it.

Concrete Lining for Steel Bunkers

When building its new plant at Duluth, Minn., the Minnesota Steel Co. also built a large circular steel tank (Fig. 1) for supplying coal to the coke plant. This tank is approximately 55 ft. in diameter, 40 ft. high and holds 2100 tons of coal. For furnishing coal for the gas producers of the openhearth furnaces there are 33 bunkers, each approximately 20 ft. wide, 12 ft. deep and 17 ft. long.

To protect these bunkers from the corrosive action of the coal, it was decided to cover the coke-oven bins with a 5-in. lining and the producer bins with a 2-in. lining of concrete, using a cement gun.

Fig. 2 shows the workmen on the inside of the round tank in the process of depositing the gunite lining. Fig. 3 is a view looking from the top into a line of parabolic bunkers after the work of gunite lining had been finished.

Numerous iron lugs were placed around the inside of the tank. To the lugs vertical rods were wired, and to the rods triangular-mesh wire cloth was secured in horizontal bands. The wire mesh was held approximately ¾ in. away from the steel and gunite was then applied. The first layer is shot through the mesh and serves to hold the wire cloth in place, thoroughly covering and protecting the steel plate. The second layer is then applied, bringing it to a total thickness of 5 in. When the work is finished the concrete is monolithic in construction and the surface is smooth and even.

The cement mortar consists of a mixture of portland cement and torpedo sand in the proportion of 1 to 3, mixed dry. It is then shot through a hose by the cement gun having an air pressure of from 40 to 60 lb. Immediately before emerging from the nozzle, the dry mixture is hydrated, the water coming through a separate and smaller hose and being under the control of the operator.

The sand in the first mixture strikes a hard surface, like a steel plate, rebounds, then falls clear of the work to the bottom in the form of clean sand and leaves a coating of cement on the surface. As soon as this coating has attained an appreciable thickness, it acts as a matrix into which subsequent deposits of material embed themselves so that the gunite in contact with the steel plate is clean cement. As a result of this, and of the pressure under which it is applied, the adhesion of the gunite to the flat steel plate runs as high as 500 lb. per sq.in.

This work was executed by the Gun-crete Co., 914 So. Michigan Ave., Chicago, Ill.

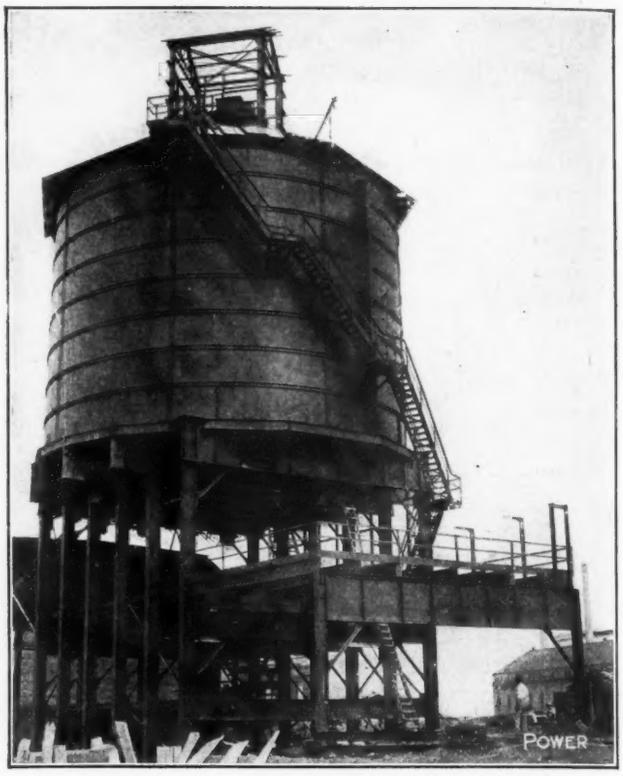


Fig. 1. A 2100-Ton Capacity Coal Bunker Lined with Gunite

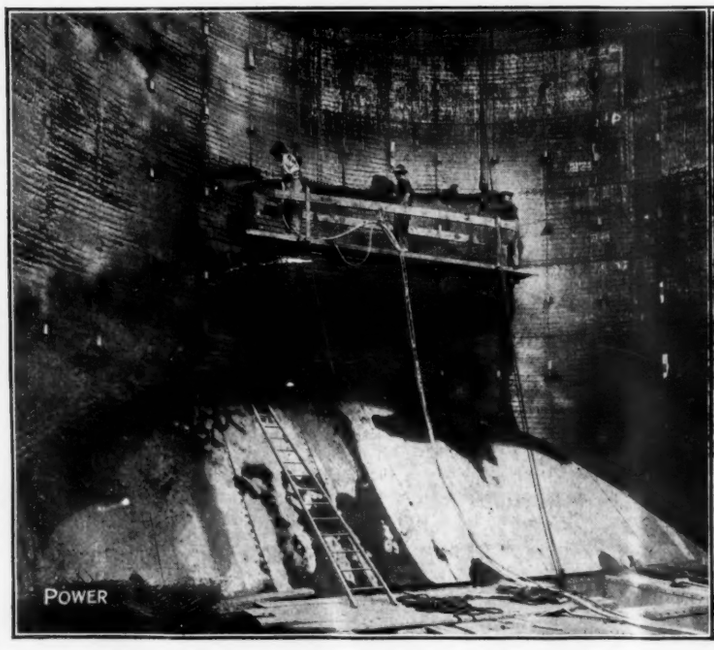


Fig. 2. Process of Lining a Coal Bunker with Gunite

Fig. 3. Finished Interior of Coal Bunker Lined with Gunite

Editorials

High-Pressure Boilers

Since the advent of the steam engine the pressures employed have tended upward. Watt commonly used ten pounds gage and set twenty pounds as the safe limit. Years later Corliss considered a pressure above sixty pounds as unsafe, and at the time it probably was. Such men as Thurston and others prominent in the field realized the advantages of high pressure and it was not long before stronger materials and better designs allowed a considerable advance in this direction. In present-day practice one hundred pounds is conservative even for small plants, two hundred pounds is not uncommon in large generating stations and in marine service water-tube boilers have carried a pressure as high as three hundred and seventy-five pounds.

It is generally conceded that economy increases with the pressure and at a faster rate than would obtain by superheating the steam, although the latter is of importance in reducing initial condensation and in turbines the drag and wear resulting from wet steam. This being the case, practice might be improved by bettering the facilities at hand to safely generate high-pressure steam and perfecting prime movers to utilize this steam to advantage. For the latter, available lubricants and materials of construction limit the working temperature to about six hundred degrees. A pressure of six hundred pounds falls considerably below this limit and might be used in heavily constructed engines having balanced poppet valves or in turbines especially made for the pressure. There is no question that higher pressures pave the way for gains in economy and make possible greater concentration of the power plant. Attempts to continue the general advance in pressure, then, are well worth while, and the effort described on other pages of this issue should be received with interest.

The boiler is of the wet-tube variety and as a consequence does not possess the nonscaling advantage of the flash boiler. In every water-tube boiler using water which has not been previously treated or distilled, scale is sure to form, and in the greatest quantity at the point where the circulation is least active. In the average horizontal water-tube boiler the tubes just above the center of the bank fill up rapidly, and in the type of boiler under discussion much the same action might be expected. With no special provision for inspection or openings through which the scale might be attacked directly, a boiler is under a serious handicap, and this appears to be the weak point of the present design. It is hardly safe to depend on mechanical vibration imparted from the outside or the action of a light fire on dry tubes. Some scale could be removed in this way, but a more positive method is preferable.

It is claimed that the boiler was built to demonstrate the principles advanced and that the construction can be varied to suit requirements. It would be possible to continue the bronze screw plugs, shown on the rear header opposite the two bottom tubes, up to the top if necessary. This would give a direct opening to each tube, permitting inspection and the use of a positive scale remover. Much of the trouble caused by scale could, of course, be obviated by using distilled water in the boiler or by previously treating the feed. The advantages from the higher pressure would no doubt warrant this extra trouble and expense.

Another apparent difficulty would be the regulation of a coal fire to the varying demands upon a boiler with so little heat-storing capacity. With a good bed of fuel burning briskly to carry the normal load on the boiler, it would seem impossible to dampen its effect immediately upon a sudden falling off of the load. Tests conducted to settle this point showed a rise in pressure of only fifteen pounds. Considering the large factor of safety, this small increase is negligible. It would be perfectly safe to set the safety valve above the working pressure and allow whatever margin was necessary to prevent waste of steam.

As stated in the article, the sections can be easily removed for repairs. The repairs, however, require the use of a welding outfit and an operator capable of using it. The alternative is to return the damaged section to the shop, first replacing it by a new element held in reserve. Keeping a number of these sections on hand lessens the necessity for reserve capacity in extra boilers. This is one of the arguments presented in favor of the boiler and it is worth considering.

Safety First in the Power Plant

For more than thirty years POWER has been striving for legislation which should put some safeguard around the design, construction, installation and use of steam-generating and using apparatus.

There is no industrial country which has so little legislation of this kind as the United States—and none which has so many boiler explosions.

In all but a few states and municipalities the design and construction of a boiler are left to the boiler maker. If they are done with intelligence and integrity it is because of the boiler maker's regard for his reputation.

There is nothing beyond his honest craftsmanship or the fear of disclosure to prevent him from using bargain material or money-saving but risky methods in meeting competition or making an extra profit.

There is nothing to prevent a user from putting a boiler into service for which it is not designed nor fitted; from putting second-hand junk under dangerous pressure; from keeping boilers at work after they have reached the age and condition of retirement; from putting boilers and engines in charge of men who do not know enough about them to handle them safely, especially in emergencies. There is nothing to require the user to provide his boilers and engines and their surroundings with the appliances and fittings and conditions, intelligently installed and maintained, which are necessary for their safe operation.

As a consequence there are, under sidewalks and in buildings of all kinds where hundreds of people pass and

congregate, boilers more dangerous than dynamite cartridges, in charge of men of the kind who will do the arduous work of keeping them running for the least money.

And as a consequence, there were last year reported in our tabular list 501 boiler accidents, causing the death of 171 and the injury of 387. The greatest number to lose their lives in a single explosion was nine and those injured (not in the same explosion) in one explosion was thirty-two. An estimate of the monetary loss was given only in 120 cases, but the total for this number was approximately $213,000, or an average of $1775. The greatest loss reported was $40,000.

Efforts for corrective legislation have been persistently, and for the most part successfully, opposed by the large users of boilers and employers of engineers; the railroads, the public-service corporations, manufacturing interests; and by engineers who did not feel sufficiently sure of their mastery of their business to submit with confidence to an examination. The employers see in it a menace of restriction in the number of available engineers and boiler attendants which may be abused by the labor organizations, or the specter of a new public official to be kept in good and complacent humor. The engineers, overlooking the fact that the state can go no further than to insist that the man in charge of a steam plant shall be a *safe* man for the position, are terrified by the accounts of examinations given by those who exaggerate their difficulty to magnify their prowess in passing them or to excuse their failure to get through.

A proper law, intelligently administered, will be free from both these evils, and the efforts of the opponents should be directed rather to forestalling these abuses than to opposing legitimate and necessary safeguards to the public safety from apprehension that their possible abuse may lead to their personal inconvenience or loss.

The effort has now extended to a wider and higher plane. A committee of the American Society of Mechanical Engineers, the professional organization best equipped to deal with the subject, presented at the recent meeting of that society a code of boiler rules and specifications which embodies the results of months of study and discussion by all classes interested, from the steel makers to the operating engineers who run the boilers. The boiler makers are organized for the purpose of urging the adoption of these rules by all the states, that they may be relieved from the difficulties occasioned by conflicting laws and that their product may be standardized the country over. It is hoped and expected that every state in the union will enact a law requiring the inspection of boilers and the examination and licensing of engineers, either by an existing department or by a department created for the purpose, and that the code of the American Society of Mechanical Engineers will be universally adopted by those having the administration of such laws in charge. There should then be a national organization of the members of such boards who, in annual convention, would discuss the problems of their administration and desirable additions to or modifications of the rules, to the end that such changes should be general and uniformity maintained. The board in each state should be directed to investigate and report upon every serious accident to a boiler or other pressure vessel occurring in that state, which would lead to a thorough and intelligent census of such accidents and an analysis of their causes which would indicate the modifications of the code most needed.

It is the most pronounced single demonstration of the Safety First movement in the industrial field and we hope to see it make more progress during the coming year than it has in all the years that have gone before.

Engineering at Sargent's Wharf, Boston

The series of articles beginning in this issue and describing the equipment and operating methods in what is, we believe, the largest refrigeration system in the world, that of the Quincy Market Cold Storage & Warehouse Co., Boston, treats of the unusual practice and design as found in the company's chief station, the Sargent's Wharf plant on Eastern Ave. The refrigeration system embodies two large stations, seventeen large warehouses, and a street system having approximately six miles of piping and supplying eight hundred separate services.

Boston is one of the greatest market places in the world, and millions of dollars' worth of the produce coming into that city is refrigerated by this company, both in its own warehouses and by cold brine served through its street system as water is distributed to a city from a reservoir. Much of the service is sold on a guarantee that the temperature will not vary more than one degree. It is important to the value of all the stored goods that the service be not interrupted. If the load of a light or power station is dropped it can be picked up where it was dropped, but if this refrigeration load is interrupted, the temperature continues to so increase that perhaps by the time the service is resumed, the temperature rise is such as to require hours to get it back to normal.

The nature of the service explains certain peculiarities of design and operating practice, at first thought seemingly extreme. Every feature of design, every move in operating, must be thought out and executed to the end that unintentional interruption will be only remotely possible. An idea of the importance of uninterrupted service may be had from the statement that at present one-hundred and fifty million dollars' worth of perishable produce is refrigerated by one compressor.

In this plant, one finds by far the largest ammonia compressor ever built, it being of 1000 tons capacity at a speed of sixty-five revolutions per minute, but its normal speed is seventy-five, at which it is capable of developing approximately fifteen hundred tons. The articles treat thoroughly of the design of this machine. The amount of refrigerated brine pumped daily in hot weather is greater than the water consumption of many a large city. The brine-pumping engines run at exceptionally fast speeds. Turbo-generators furnish light and power for the station and for Boston's great meat clearing house, Clinton Market.

To rebuild by the aid of the plant's own crew worn and antiquated equipment, modernize it, thus carrying a high maintenance charge, but practically none for depreciation or obsolescence, is one of the many unusual practices in the plant. The articles are not in the nature of mere plant description, but rather treat of the details of all the important engineering practice as found in this unusually well conducted system.

Correspondence

Comment on Diagrams

Referring to Mr. McNamm's indicator diagrams from the high-pressure cylinder of an 18 and 32x24-in. condensing engine, published in the Nov. 3 issue, I submit the following:

The trouble is evidently caused by the eccentric slipping on the shaft, reducing the angle of advance and making all the events late.

The head-end diagram shows that the admission line is at the right-hand side instead of at the left, and therefore it will be seen that admission does not occur until about 25 per cent. of the stroke has been completed. During that time the pressure drops because steam is being drawn from the receiver by the low-pressure cylinder. The admission line inclines to the left because the piston is moving rapidly and cutoff is delayed until about 80 per cent. of the forward stroke has been completed. Expansion is not completed at the dead center, therefore the steam is compressed until release takes place at about 25 per cent. of the return stroke and the pressure again drops to that of the receiver.

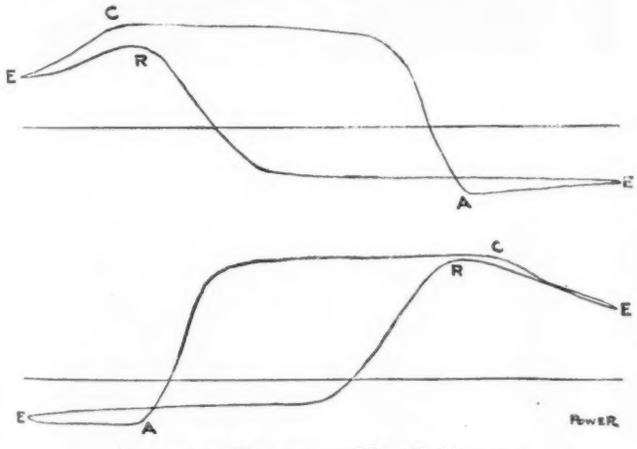
It will be noted that admission on the crank-end diagram is at the left-hand side and that it shows the same general characteristics as the head-end diagram.

The pound mentioned was caused by the abrupt reversal of pressures occurring near the point of release.

E. H. Sawers.

Buffalo, N. Y.

I offer the following: The receiver pressure is too low, being below the atmospheric line. The valve action is late for all events. Admission *A* is at about one-quarter stroke in the head end and one-fifth stroke in the crank end. The expansion line extends from *C*, where cutoff occurs, to the end of the stroke *E*. As the exhaust port does not open until the piston travels about one-half to one-fifth of the return stroke, the steam is compressed for this period instead of being exhausted into the receiver. From *E* to *R*—that is, from the end of the stroke to the point of release, which should be the exhaust line—the line travels nearly parallel with the expansion line *CE*, but it is slightly lower on account of the drop in pressure due to cylinder condensation.



Diagrams Taken by Mr. McNamm

The same thing occurs, and for the same reason, from *E* to *A*, the end of the stroke to the point of admission. The heavy pounding when passing the center is, of course, due to lack of compression. The compression from *E* to *R* takes place at the beginning of the stroke and should therefore not be confounded with the compression at the end of the stroke.

The remedy lies in advancing the eccentric until proper admission is obtained.

Victor Bonn.

New York City.

Interesting Cylinder Failure

I quote Mr. McLaren's statement in the Nov. 3 issue: "With the engine running forward and the valve-gear in the forward position, I do not see how water could be pumped, assuming that the piston is traveling toward the head end and that the head-end exhaust valve is open and the steam valve is closed. Any water which might be in the cylinder would have a chance to escape through the exhaust valve until compression begins."

I call Mr. McLaren's attention to the fact that while normally the receiver pressure is low, the terminal pressure might be such that when the engine is started light and steam is admitted into the receiver through a bypass, or, due to a sudden decrease of load, when the steam in the cylinder would be expanded below the receiver pressure, water that might have accumulated in the receiver would be pumped into the cylinder and probably cause damage.

Victor Bonn.

New York City.

Failure of Concrete Dam

The article in the Oct. 27 issue, page 622, describing the failure of a concrete dam at Marble Rock, Iowa, was interesting. In the fall of 1912 I was asked to go there and confer with those interested in the hydro-electric power project for Marble Rock. I strongly advised that the hydro-electric project be abandoned in view of the character of the foundation, etc., and that a small steam or oil-engine plant be installed at a much lower first cost, as the saving in fixed charges would easily offset the increased operating expense.

If, however, they decided to have a hydraulic plant, I suggested that the dam be built at a point three or four miles down the river where a suitable foundation was available. Evidently my recommendations (and incidentally my bill for services also) were overlooked, for later some contractor furnishing engineering services free installed a hydraulic plant for the town.

With the $15,000 loss, the economic loss to the com-

munity or state still remains. It is not often that bad engineering is so quickly and thoroughly shown up as in this case. This instance should be brought to the attention of managers of power plants and industrial properties of all kinds.

Much dangerous construction is going on, not to speak of those numerous instances where thousands of dollars are wasted because those in charge of the work lack the proper experience and are unwilling to pay for the services of competent engineers.

J. C. LATHROP.

Cleveland, Ohio.

Home-Made Feed Heater

In an account of a home-made feed heater in the issue of Oct. 6, p. 502, together with some data as to results, S. J. Robinson claims to have secured a high rate of heat transfer per foot of heating surface.

The weight of water heated per hour is given as 34,550 lb. raised from 110* to 200 deg. F., which absorbs 3,105,000 B.t.u. Assuming that steam at atmospheric pressure or slightly above is used, the heat (latent) available per pound of steam would be about 970.4 B.t.u., and at this rate the heater would have to have approximately

$$\frac{3{,}105{,}000}{970.4} = 3199.7 \text{ } lb.$$

of steam per hour passing through and rendering up all its latent heat, which would be unlikely to occur.

Furthermore, from the drawing there appear to be 17 tubes, which would give the total heating surface of about 14.5 sq.ft., requiring a heat transfer per square foot per hour of over 230,000 B.t.u.; this is entirely too high. Even with ten times the heating surface the heat flow would be phenomenal. Roughly, the heating surface necessary to deal with the given weight of water based on 15 lb. of steam condensed per square foot of effective surface per hour would be 230 sq.ft.

E. H. PEARCE.

Rochdale, England.

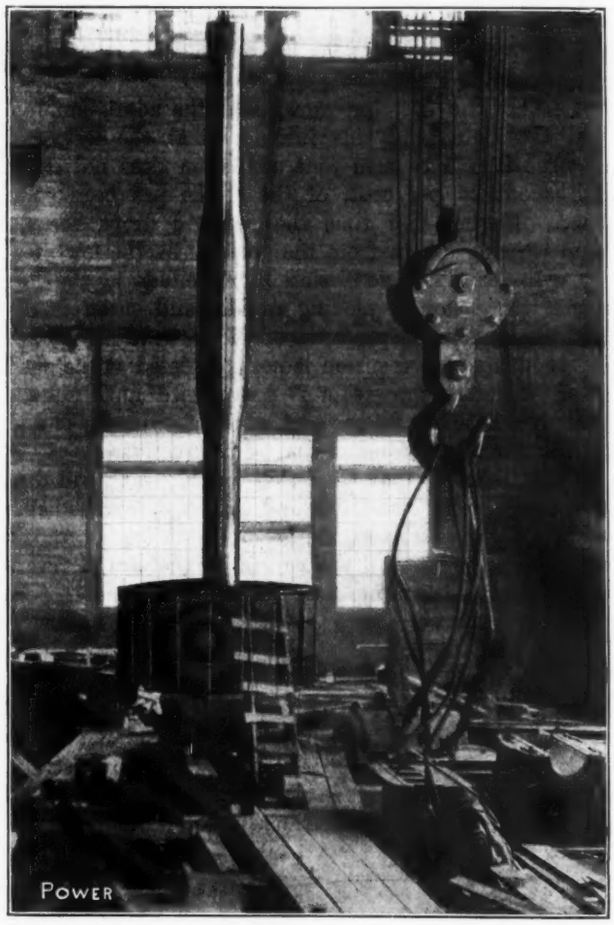
Novel Method of Making a Shrink Fit

In erecting the Drum power plant of the Pacific Gas & Electric Co., the engineers were confronted with an unusual job. The 12,500-kw. generators are of the revolving-field type, each driven by two 10,000-hp. Pelton-Doble waterwheels (one at each end), and the revolving field is mounted on the same shaft between the two bearings. The main shaft is 26 in. diameter and is made of chrome-nickel steel, and hollow. The rotative speed is 360 r.p.m. and may exceed 700 r.p.m. should an accident occur to the governor.

The kinetic energy of the generator is 38,000,000 ft.-lb.; in other words, if the water were suddenly shut off, the flywheel effect of the rotor alone would deliver 20,000 hp. for more than three seconds. It can be seen that a press fit of extraordinary tightness was advisable to prevent either the waterwheel or the generator-rotor disks wrenching loose or slipping under extreme conditions. An allowance of 0.008 in. was specified, and it was estimated that a force of 750 tons would be required. To rig up for such heavy work in an isolated location, without any type of hydraulic press, was the problem before the erectors.

Incidentally, as the rotor was approximately 48 in. in length, the metal of the shaft would in all probability drag and tear, resulting in an unworkmanlike job. For these reasons it was decided to heat the disks for a shrink fit on the shaft. The core of the revolving field was built up of a number of 2-in. disks, so that oil torches or similar methods of heating were deemed inadvisable for fear of distortion due to uneven heating.

Instead, a mammoth caldron, large enough to hold the entire field core, was built, the core placed in it, covered



SHAFT IN POSITION TO LOWER

with water, and then heated by fires built about the sides. The water was kept at the boiling point for 48 hr. The core was then lifted by a traveling crane and set on blockings previously arranged. On measuring the hub bore, it was found that the expansion had amounted to 0.02 in., with a temperature rise of 150 deg. F. The shaft was then suspended vertically, lowered into place in the core, and blocked without difficulty.

It is interesting to note that the quantity of heat stored in the metal of the core was so great that it required cooling for 24 hr. before it had shrunk sufficiently to grip the shaft.

This same method was applied to both units, there being three fits on each shaft, or six in all. Two more units of similar size will be installed in the near future and assembled in the same manner.

WALTER SWAREN.

Hayward, Calif.

*[In the original letter, a typographical error occurred in the table; it should read (200-110) to agree with the statement in the text.—EDITOR.]

Stresses in Convex Heads

In the July 7 issue appeared a mathematical analysis of the stresses in convex heads by F. G. Gasche, the results of which are rather at variance with opinions previously expressed in these columns.

The resultant formula brings the thickness of convex heads up to three times what is now required as a minimum by existing rules, or, expressed differently, the present minimum factor of safety of 5 becomes 15.2, there being in effect no other difference in the proposed formula of the author as compared with

$$P = \frac{t \times T.S.}{\frac{1}{2} R \times 5}$$

Mr. Gasche's formula is:

$$P = \frac{t \times T.S.}{1.52\ R \times 5}$$

This would undoubtedly make the convex head considerably safer. However, with this proposed higher factor of safety goes the recommendation that the flange turn must be of as small a radius as is practically possible to make it, although a sharp corner must be avoided. It is held presumably that the tangents of the spherical part of the head should run as closely to the point O', Fig. 1, as possible, so that the lever-arm l_1 and consequently the moment Tl_1 will be reduced to a minimum. This is also in line with the vital conclusion of the analysis that the outer skin of the flange turn at A is subject to tension and the inside at B to compressive strains. It is peculiar how a purely theoretical analysis may sometimes lead to just the opposite of what one should judge from appearances actually takes place.

In Mr. Gasche's analysis, although the mathematics seem to have been worked out carefully, it would appear that the basic assumptions on which they rest are not correct.

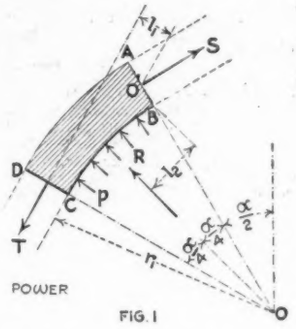


FIG. 1

FIG. 2

In Fig. 2 is represented part of a flange ring taken from a boiler where the dished sheet originally forming one piece with the ring had blown out. The many short lines running along the edge of the fracture are little cracks of varying magnitudes, while the outer skin of the flange turn along the main line of fracture is unbroken and looks smooth except for a little surface rust. From this, one would be led to believe that the metal on the inner skin was under very high tension from the time of the installation of the dished head until the final rupture occurred; at any rate, one would not expect compression at this point, while the appearance of the outer skin of the flange turn suggests no tension except at the instant of rupture. It has been found also in several cases where convex heads have failed that the heads in the adjacent boilers of the same age and construction had cracks on the inside of the turn of the flange working their way from the inside toward the outside of the flange fillet. Yet Mr. Gasche's analysis tends to show that the opposite should be expected.

First of all, the deflection of the dished part of the head under pressure load is entirely left out of the deductions by simply assuming that a purely spherical tension at the circumference is all one need expect. This wrong

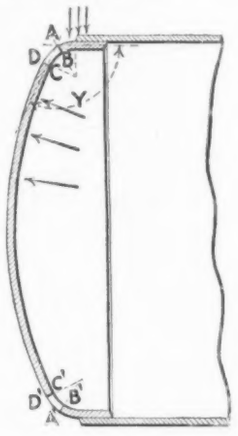


FIG. 3

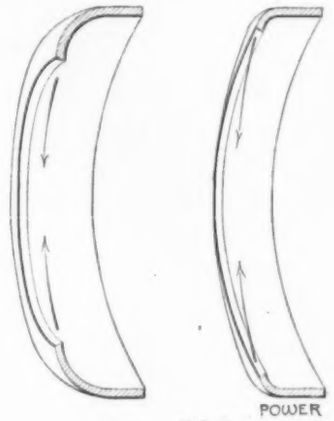


FIG. 4

assumption is as old as the convex head itself and appears to die very hard, it having been stubbornly adhered to for many years by men prominent in the boiler industry, although it has never been conclusively shown to have any foundation in fact.

Furthermore, the accuracy of the deductions appears to suffer from the fact that the author treats the lever arms l_1 and l_2 (Fig. 1) as beams with free ends, which, of course, is not actually the case in a boiler head. If argued from the standpoint of pure tension strain in the dished part of the head, the moment Tl_1 about the center O' would be opposed by a resistance against crushing in the dished part, radially from the center, which crushing resistance has not been taken into account in the analysis. Likewise, the moment Rl_2 is not opposed by merely the resistance against bending of the plate section AB, but also by the connection formed by the dished part between two diametrically opposed elements such as $ABCD$ and $A'B'C'D'$ (Fig. 3), as well as by the cohesion between the sides of the adjacent elements, because of the fact that the supposed free ends of the elements form a ring which would be subject to a stretching strain, in case the lever arm l_2 should tend to move outward. Neither of the two latter resistances has been taken into account.

It may thus be safely concluded that by the analysis here criticized, the point that the support of large spherical heads should not depend on fillets of large radius has not been conclusively proved.

The fact that the dished portion of a convex boiler head has a tendency to seek relief from stress by deflection should not need any argument. A flat, round boiler end under pressure may be properly considered as a form of beam supported all around the edges and deflection is naturally expected in such a beam similar to that in any uniformly loaded beams supported at the ends, and there is no reason to assume that such a round uniformly loaded plate should not be subject to similar deflection, as soon as it has been slightly dished. It must be admitted, however, that the degree of deflection becomes less the deeper a convex head is dished.

The stress in the turn of the flange then apparently depends on two major considerations: the flexing of the dished part and the yield toward collapse of the ring to which the dished portion is attached. These two actions cause the angle Y in Fig 3 to become larger, which produces a bending stress in the turn of the flange, the magnitude of which depends on the amount of flexure and collapse respectively, the amount of collapse probably in no case amounting to much.

Neither on the flexure of round plates under uniform load, supported around the edges, nor on the collapse of cylindrical forms have ever been produced mathematical conclusions that adequately cover these problems to such extent that tests will completely bear out their correctness. Such formulas as are in use for either of these problems are mostly based on empirical averaging of practical results, the well known Nichol's rule for boiler ends and Fairbairn's formula for cylinders subject to collapsing pressure being the most prominent and frequently quoted.

In the case of the convex head, offering a combination of these two problems, it would seem almost hopeless to search for an adequate solution by mathematical conjecturing.

Instead, the admirable work done so far with extensometers would seem to point to the only reliable way of settling the question as to whether the flange fillet of convex heads should be as small as possible or of ample curvature. Meanwhile, the contention that a good-sized fillet radius will make conditions better than with an abruptly turned flange (in which a sharp corner has been avoided), is based on the theory that the bending stresses will be distributed over a wider range of stressed area with the former, whereas, with the latter, the stress will be localized in a very narrow range. In this connection, it should also be remembered that the more abruptly a plate is flanged, the greater will be the molecular disturbance due to the flanging process in the steel of the flange heel, which is the very place at which the maximum stresses occur when a convex head is subjected to internal pressure.

Finally, the simple requirement, mentioned by Mr. Gasche, that circular riveted seams at the ends of cylindrical drums should be as near to the tangents of the spherical shell as it is structurally possible to place them, if such a requirement really exists, does not suffer any great violation by increasing the radius of the flange fillet. The idea of this simple requirement is that the overhang between the point of support and point of load should be as short as possible. Considering, however, that in the case of a series of overhanging beams being formed into a ring, such as the flange ring under discussion, not much dependence need be placed on the resistance against bending of the beams individually, since the combined structure of the beams collectively has resistance against collapsing.

In Fig. 4 are shown two flange rings with the dished part of the head omitted. It would appear that the one having the biggest radius of flange turn is a stronger ring against collapsing than the one of minimum radius flange, so that from this point of view the size of radius need not be restricted; in fact, conditions would be better in this regard with the larger fillet radius.

H. J. Vander Eb.

Hartford, Conn.

Repairing Leaks and Breaks

I have found the following repairs successful: A 4-in cast-iron pipe broke apart under a building foundation. To have the water on again as soon as possible, I used the clamp A, 6 in. wide and ¼ in. thick (Figs. 1 and 2), with sheet-rubber packing wrapped around the pipe, and two pieces of sheet copper D and D_1 6 in. wide, where the edges of the clamp came together. This job was done seven years ago and is still satisfactory.

Another 6-in. cast-iron water pipe had a 15-in. crack, Fig. 3. A piece of ¼-in. iron 4 in. wide formed to the

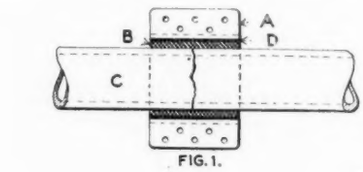


FIG. 1.

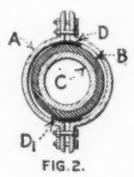


FIG. 2.

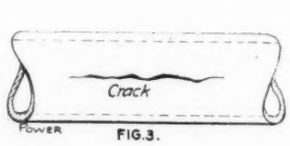


FIG. 3.

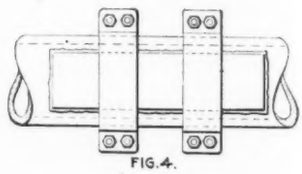


FIG. 4.

Broken Pipes Clamped

shape of the pipe, with sheet rubber placed under it, was clamped over the break, Fig. 4. This has also proved successful.

A 3-in. steam pipe leaked at the flanges because the threaded ends were badly corroded. A copper sleeve and a 5-in. pipe 8 in. long were slipped over the opening after the flanges were removed, Fig. 5. The space between the outside of the 3-in. pipe and the inside of the 5-in. pipe was then filled with Smooth-On, iron, elastic and power cement mixed. Heat from a blow-torch was then applied for half an hour and in two hours steam was turned on.

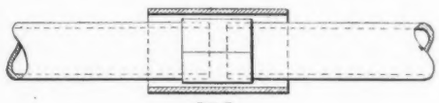


FIG. 5.

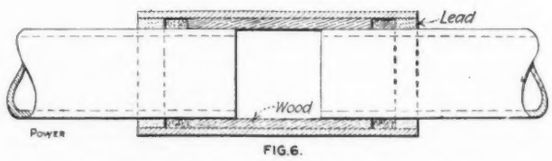


FIG. 6.

Pipe Ends Joined with Sleeves

In extending a cast-iron water main it was found that what should have been the connecting length was a foot short and there was no more pipe of the same size on hand. Instead of sending to the city for a pipe and sleeve, one of the men went into the workshop and in a few minutes turned out a wooden sleeve 16 in. long to fit over the pipe. Next a 20-in. piece of larger pipe was cut and placed over the pipe ends and the wooden sleeve, Fig. 6. The joint was then run with lead in the usual way.

James E. Noble.

Toronto, Ont.

Inquiries of General Interest

Action of Molten Iron in Solidifying—What is the behavior of molten cast iron upon cooling; does it not expand in solidifying?

F. H.

Most cast irons exhibit the phenomenon of expanding immediately after being poured in the mold and during the first process of solidifying, and of then contracting during a continuance of the process and while cooling.

Place for Obtaining Sample of Flue Gas—For boiler flue-gas analysis, at what point should the sample be taken?

G. B.

Preferably at a point where the gases are just leaving the boiler—i.e., in the case of a water-tube boiler the sample should be taken from the last pass of the furnace gases, and in that of a fire-tube boiler it should be taken from the connection between the boiler and the breeching.

Behavior of Cast-Iron Fittings—What effect has superheated steam on cast-iron fittings?

A. R.

Gray cast-iron fittings show a tendency to crack and to assume stretch when employed on superheated or high-pressure steam systems. The cracks, although hairlike at first, frequently widen from continued use, allowing enough steam to escape to make their presence noticeable.

Heat Liberated by Flue Gases—How much heat will be liberated from 20,000 lb. of flue gas reduced from 650 to 300 deg. F.?

E. R. H.

The average specific heat of flue gases is about 0.25. Hence, the liberation of heat from 20,000 lb. of flue gas in undergoing a drop in temperature of

$$650 - 300 = 350 \text{ deg. F.}$$

would be

$$350 \times 0.25 \times 20{,}000 = 1{,}750{,}000 \text{ B.t.u.}$$

Increasing Feed Temperature at Expense of Back-Pressure—In case an exhaust steam feed-water heater raises the temperature from 40 to 200 deg. F. by use of 2½-lb. exhaust back pressure on a noncondensing engine, would it pay to throttle the exhaust sufficiently to raise the feed-water temperature to 210 deg. F.?

G. F. T.

Under ordinary conditions it would not be economical to obtain such an increase in temperature of feed at the expense of increased back pressure, as the gain in heat of feed water could not compensate for the additional steam consumption of the engine for development of the same mean effective pressure.

Corrosion and Protection of Busbars—What is the whitish coating formed on copper busbars when exposed to coal gas from passing railway locomotives, and how can such deposits be removed and prevented?

L. S.

Since the busbars are exposed to coal gas, and probably also to moisture, the copper is attacked by sulphurous acid forming a white sulphate. The deposit can be removed by scraping; or perhaps moistening the busbars with a very dilute sulphuric acid, all traces of which should be removed by rubbing down the busbars with waste moistened in clean water. To prevent further chemical action the busbars, after being thoroughly cleaned, should be lacquered.

Raising Liquor by Air-Jet Lift—For transferring a warm liquor from one tank to another, a steam siphon is found to be objectionable, as the condensed steam mingles with the liquor. What type of air pump or other air appliance can be used, the liquor having a density of about the same as that of sea water and the tanks being each 13 ft. in diameter by 8 ft. deep?

K. P. H.

Assuming that aeration of the liquor is not objectionable and that a supply of compressed air is available, a convenient method of transferring the liquor from one tank to another would be by an air-jet lift, which should be placed below the lowest level of the liquor which is to be elevated.

Placing Patch on Horizontal Return-Tubular Boiler—Should patches on the shell of a horizontal return-tubular boiler be placed on the inside or the outside of the boiler?

C. M.

Generally speaking, it is better to place a patch on the inside, as in putting on a patch the riveting and calking tend to flatten the curvature of the shell, and when the patch is placed on the outside the calking is more likely to become opened by the effort of the shell to assume a circular form when under pressure. Patches below the water-line always should be placed on the inside, otherwise a pocket of a depth equal to the thickness of the shell plate is formed inside and soon becomes filled with sediment which may cause the patch to become burned.

Detecting Grounded Bar of Stator—What method may be employed for detecting a grounded coil of the stator of a three-phase induction motor without removing the rotor?

M. F. K.

With any source of direct current, preferably 110 volts, connect one side to the motor frame and the other side to one lead from a lamp socket. Untape the stator windings where the phases join and with the other lead from the lamp, test each phase. The one grounded will cause the lamp to light. Having determined this, untape several groups of coils and in this way find which group the trouble is in and similarly locate individual coils which may be grounded. Also, a voltmeter may be used for this purpose, or a telephone receiver with a low voltage current, as explained in connection with direct-current armatures in the Nov. 3 issue of "Power." Also see "Short Circuits and Grounds in Field Coils," Sept. 1 issue of "Power."

What Becomes of the Heat in the Fuel—What becomes of the heat which is supplied in the form of fuel to the boiler furnace of a noncondensing steam-power plant?

J. S.

The heat losses and utilization of the heat in the coal will vary with different plants and different conditions in the same plant. In the average steam-power plant, using a noncondensing engine and exhaust steam feed-water heater, the heat of the fuel supplied to the boiler furnace is distributed in about the following proportions:

	Per Cent.
Lost through the grates	1.5
Lost by radiation from boiler and setting	5.5
Lost in chimney gases and incomplete combustion	25.0
Lost by radiation from steam pipes	1.5
Delivered to pump	1.5
Lost by radiation from engine	2.0
Lost in engine friction	1.0
Lost in engine exhaust	55.0
Utilized as power delivered by engine	9.0
Total	100.0

Evaporation Under Stated Conditions—With coal showing 14,000 B.t.u. per lb., an efficiency of boiler and grates of 68 per cent. and a feed-water temperature of 200 deg. F., how many pounds of water per pound of coal would be evaporated into steam at 150 lb. gage pressure?

M. G.

There would be 68 per cent. of 14,000 or 9520 B.t.u. available from each pound of coal. Gage pressure of 150 lb. per sq.in. would be equal to about 150 + 15, or 165 lb. absolute, and, according to the Marks and Davis steam tables, a pound of dry saturated steam at that pressure has a total heat of 1195 B.t.u. above 32 deg. F. With the feed water at 200 deg. F.—i.e., 200 — 32, or 168 deg. F. above 32 deg. F.—then, for conversion into steam of the stated pressure, each pound of water would receive

$$1195 - 168 = 1027 \text{ B.t.u.}$$

and with 9520 B.t.u. available from each pound of coal, the evaporation under the conditions would be

$$\frac{9520}{1027} = 9.26 \text{ lb.}$$

of water per pound of coal.

[Correspondents sending us inquiries should sign their communications with full names and post office addresses. This is necessary to guarantee the good faith of the communications and for the inquiries to receive attention.—EDITOR.]

Engineers' Study Course

Problems in Power-Plant Design--VIII

Fans and Heaters

Before taking up the design of the heating and ventilating apparatus for the different buildings, it may be well to give a small amount of general data relating to the more important parts of the equipment used for this purpose. The centrifugal fan with steel housing is the type almost universally used for this class of work. It is not only compact and self-contained, but produces a higher pressure than a disk fan under similar conditions, and is therefore better fitted to overcome the resistance caused by long runs of piping with more or less frequent bends and offsets. Casings may be had with either one or more outlets arranged to discharge the air at any angle desired, thus lending themselves readily to installation in a variety of locations.

While the relative proportions of wheel and casing vary somewhat with different manufacturers, in a number of standard makes examined, the width of wheel at the center was found to be about 0.52 of the diameter. Although in some makes the outlet is given a greater height than width, it is more customary to make it square with a dimension each way about 2 in. greater than the width of the wheel. These dimensions are especially noted because they are assumed in the computations and tables which follow.

While the efficiency of a fan increases up to a peripheral velocity of about 8000 ft. per min., it should not exceed about 3500, where quietness of operation is required, as in schools, churches, etc. For shops and factories, where a certain amount of noise is not objectionable, the peripheral velocity may be increased to 5000 ft. or more with good results.

In general, the volume of air delivered by a fan varies directly as the speed, and the power as the cube of the speed. That is, doubling the speed will double its capacity, but will require eight times the power to drive it. This increase in power applies only to ideal cases, and does not take into account the efficiency of the fan. However, the power increases much more rapidly than the volume of air delivered, even under practical conditions, and should always be borne in mind when the matter of speeding up a fan to increase its capacity is under consideration.

Under the conditions of hot-blast heating as applied to machine shops and foundries, the capacity of a centrifugal fan is given approximately by the formula

$$V = 0.43 \times C \times R \times O$$

in which

V = Volume of air moved in cubic feet per minute;
C = Circumference of fan wheel in feet;
R = Revolutions per minute;
O = Area of outlet in square feet.

Table 1 gives data for use with the above formula.

TABLE 1—FAN DIMENSIONS

Diameter of Fan Wheel, Over All, Ft.	Circumference of Fan Wheel (C), Ft.	Area of Outlet (O), Sq.Ft.
3	9.4	2.9
3½	11.0	3.9
4	12.5	5.0
4½	14.1	6.2
5	15.7	7.6
5½	17.3	9.1
6	18.8	10.7
7	22.0	14.4
8	25.1	18.6
9	28.3	23.4
10	31.4	28.7

Table 2 has been computed by the formula, for fans having speeds of approximately 5000 ft. per min. peripheral velocity, and also gives the brake-horsepower of motor for driving them at these speeds.

TABLE 2—FAN SPEED, DELIVERY AND HORSEPOWER REQUIRED

Dia. of Fan, Ft.	Speed, R.p.m.	Volume Delivered, in Cu.Ft. per Min.	B.Hp. of Motor for Driving Fan
3	530	5,400	5
3½	450	8,500	6
4	400	10,400	7
4½	360	13,400	8
5	320	16,300	10
5½	300	20,100	13
6	270	23,200	15
7	230	31,300	18
8	200	40,800	24
9	180	51,300	32
10	160	62,000	40

In using Table 2 select the size which, at the given speed, delivers the volume of air nearest to that required, and make the necessary change in speed.

Example—What size and speed of fan will be required to deliver 38,000 cu.ft. of air per minute under the conditions of shop or factory heating, and what horsepower of motor will be required for driving it?

From Table 2 an 8-ft. fan at 200 r.p.m. will deliver 40,800 cu.ft., which is the nearest to that required. Therefore, a fan of this size should be used and run at a speed of

$$\frac{38{,}000}{40{,}800} \times 200 = 186 \ r.p.m.$$

The change in horsepower is found as follows: While, theoretically, this varies as the cube of the speed, it will be found under actual working conditions, for variations of 50 to 75 r.p.m. either side of the speeds given in the table, that the horsepower varies approximately as the square of the speed. Hence, for any change within these limits, divide the new speed by the old, square the result, and multiply this by the old power taken from the table. In the above example, the old speed is 200, the new speed 186 and the old power from the table, 24. Therefore, at the new speed

$$\left(\frac{186}{200}\right)^2 \times 24 = 20.7 \ hp.$$

will be required.

Practical Application

Having decided upon the method of computing the size of fan and motor, and the approximate speed at which they are to operate, let us apply these to the various buildings of the plant under consideration. Taking up the machine shop first, there are two conditions to

fulfill in determining the volume of air to be handled by the fans. First, the volume should be sufficient to carry in the required amount of heat for warming the building, within a normal working range, say between 60 deg. and 140 deg.; and second, the fans must be of sufficient capacity to give to the building three complete air changes per hour in mild weather. The required volume for each should be computed, and the fan capacity made large enough for the greater. Assuming the normal temperature of the building to be 60 deg., and the temperature of the air delivered by the fan 140 deg., which may be taken as average conditions, the rise in temperature will be

$$140 - 60 = 80 \ deg.$$

In cooling 80 deg. it gives off

$$80 \times \tfrac{1}{55} = 1.4 \ B.t.u.$$

Therefore, the total heat required per hour for warming divided by 1.4 will give the cubic feet of air to be moved by the fan.

Previous computations have shown that in the case of the machine shop 3,409,000 B.t.u. are required for warming the building in zero weather, hence

$$3{,}409{,}000 \div 1.4 = 2{,}435{,}000 \ cu.ft.$$

of air must be moved per hour for transmitting the required amount of heat. Computing the volume on the basis of ventilation with three complete air changes per hour, it is found that

$$1{,}760{,}000 \times 3 = 5{,}280{,}000 \ cu.ft.$$

are required per hour, or

$$5{,}280{,}000 \div 60 = 88{,}000 \ cu.ft. \ per \ min.$$

As this is the larger volume, the fans must be proportioned on this basis. In a building of this size it will be best to use two fans having a capacity of 44,000 cu.ft. each. Table 2 shows that an 8-ft. fan at 200 r.p.m. will deliver 40,800 cu.ft. of air per min. and requires 24 hp. Hence, in the present case two 8-ft. fans will be used, each running at

$$\frac{44{,}000}{40{,}800} \times 200 = 216 \ r.p.m.$$

and requiring a motor of

$$\left(\frac{216}{200}\right)^2 \times 24 = 28 \ hp.$$

Taking up the other buildings and rooms to be ventilated, in a similar way, and using data on heat requirements and air supply already computed in a previous article, gives the following:

For the foundry the heat requirements are 1,007,800 B.t.u. per hr. In this case, the normal temperature of the building is only 50 deg. and the heat requirements are divided by

$$90 \times \tfrac{1}{55} = 1.6$$

to get the air volume, which is

$$1{,}007{,}800 \div 1.6 = 629{,}875 \ cu.ft. \ per \ hr.$$

The computed air supply for ventilating purposes in this case is 600,000 cu.ft., so the larger volume will be used, which is

$$629{,}875 \div 60 = 10{,}498 \ cu.ft. \ per \ min.$$

requiring a 4-ft. fan at approximately 400 r.p.m. driven by a 7-hp. motor. This building is to have a vent or discharge fan also of the same capacity.

In the forge shop the heat requirements are 378,840 B.t.u., requiring

$$378{,}840 \div 1.6 = 236{,}775 \ cu.ft.$$

of air per hour. The computed volume for ventilation was 200,000 cu.ft.

$$236{,}775 \div 60 = 3946 \ cu.ft. \ per \ min.$$

for which a 3-ft. fan at 320 r.p.m. may be used, requiring a 3-hp. motor.

The total air volume for the remaining rooms, which are to be supplied by a single fan, are as follows: Offices, 403,200; toolroom, 268,800; drafting room, 378,000; pattern shop, 252,000. This makes a total of 1,302,000 cu.ft. per hr., or

$$1{,}302{,}000 \div 60 = 21{,}700 \ cu.ft. \ per \ min.$$

A 6-ft. fan at 270 r.p.m. may be used in this case with a 15-hp. motor. This gives a small surplus, which is on the side of safety, the capacity from Table 2 being 23,200 cu.ft. per min.

Heaters

The heaters used for hot-blast work in shops and foundries are of two general types, those made up of wrought-iron pipe screwed into cast-iron bases or headers, and cast-iron sections of the pin type, designed and connected up for this particular class of work. In designing a heater of this general type, three requirements must be kept in mind: It must be of sufficient depth to give the desired final temperature to the air; it must contain sufficient radiating surface to give off the total amount of heat required for warming and ventilating purposes, and must have sufficient free area between the pipes for the flow of air without producing an excessive velocity.

Both the efficiency and final temperature will vary with the temperature of the entering air, the steam pressure and the velocity of the air through the heater. The efficiency will be increased by increasing the velocity of flow, but the final temperature will be diminished; that is, a larger quantity of air will be heated to a lower temperature in the second case, and while the total heat given off is greater, the air quantity increases more rapidly than the heat quantity, which causes a drop in temperature. Increasing the number of rows of pipe, or depth of heater, with a constant air velocity, increases the final temperature but diminishes the efficiency, because the average difference in temperature between the steam and air is less. Increasing the steam pressure in the heater increases both the final temperature of the air and the efficiency of the heater.

Considerable data have been published in the last two or three years relating to the results obtained from heaters of this type under different conditions. Table 3 has been prepared for the average practice in shop heating, where exhaust steam is utilized in the coils at, or slightly below, atmospheric pressure, and where the air passes through the heater at an average velocity of about 1200 ft. per min. It is also assumed that the temperature of the entering air is zero.

TABLE 3—TEMPERATURES AND HEAT GIVEN OFF

Rows of Pipe Deep	Final Temp. of Air, Deg. F.	B.t.u. Given Off per Sq.Ft. of Heating Surface per Hour
8	55	2100
12	80	2000
16	100	1900
20	115	1800
24	130	1700
28	140	1600

The free area through a standard-pipe heater will not vary much from 0.4 of the overall or gross area, and this relation may be used when checking a given heater for maximum velocity.

Table 4, arranged by the writer some years ago, gives

approximate dimensions of pipe heaters of standard type and may be used in the design of the heaters in the present plant.

TABLE 4—DIMENSIONS OF STANDARD-PIPE HEATERS

Width of Section, Ft.	Height of Pipes, Ft.	Sq.Ft. of Heating Surface	Width of Section, Ft.	Height of Pipes, Ft.	Sq.Ft. of Heating Surface
3	3½	20	5	6½	62
3	4	22	5	7	67
3	4½	25	6	6½	75
3	5	28	6	7	81
4	4½	34	6	7½	87
4	5	38	6	8	92
4	5½	42	7	7½	98
4	6	45	7	8	103
5	5½	52	7	8½	109
5	6	57	7	9	116

The square feet of heating surface given above are for a single row of pipes. When computing the overall dimensions allow one foot in height for the base in addition to the pipes; and the same amount on the width for the supply and return headers.

Taking up the design of the heaters for the machine shop we have the following conditions. Dividing the work equally between two heaters, and assuming two air changes per hour in zero weather, gives the heat quantity to be supplied by each heater under maximum conditions.

In the fourth article of the present series the heat requirements for the machine shop were 3,409,000 B.t.u. per hr. for heating and

$$2 \times 1{,}920{,}000 = 3{,}840{,}000 \ B.t.u.$$

per hr.-ft. for ventilation. The air volume is 3,520.000 cu.ft. per hr.

The first step is to determine the final temperature to which the air must be raised, in order to find the required depth of heater and the efficiency to be expected. The heat required for ventilation is simply for raising the given volume of air from 0 to 60 deg., the temperature of the room, so does not enter the computation. The problem therefore becomes: Through how many degrees must this volume of air be raised to bring in the B.t.u. required for warming the building? This rise in temperature added to 60 deg. will evidently give the final temperature. The formula for this is

$$T = \frac{55\ H}{V}$$

in which

T = Rise in temperature in degrees;

H = B.t.u. to be given to the entering air per hour;

V = Volume of air, in cu.ft. entering per hour.

Substituting the given quantities in the formula, gives

$$T = \frac{55 \times 3{,}409{,}000}{3{,}520{,}000} = 53$$

from which the final temperature is found to be

$$53 + 60 = 113 \ deg.$$

Referring to Table 3, this will require a heater 20 pipes deep, and the radiation per square foot of surface per hour will be 1800 B.t.u., which calls for a total heating surface of

$$\frac{3{,}409{,}000 + 3{,}840{,}000}{1800} = 4027$$

or practically 4000 sq.ft., making 2000 sq.ft. in each heater. If the heater is to be 20 pipes deep, each row must contain

$$2000 \div 20 = 100 \ sq.ft.$$

of heating surface, which from Table 4 corresponds closely to a section 7 ft. wide by 8 ft. high. Checking for velocity, there is a free area of

$$7 \times 8 \times 0.4 = 22.4 \ sq.ft.$$

The volume of air passing through the heater per minute is

$$\frac{3{,}520{,}000}{60 \times 2} = 29{,}333 \ cu.ft.$$

which gives a velocity of

$$\frac{29{,}333}{22.4} = 1309 \ ft. \ per \ min.$$

This is within the usual limit of about 1500 ft. per min.

In the foundry the air supply for limiting the temperature of the entering air to 140 deg. was found to be 629,875 cu.ft. per hr., which calls for

$$\frac{629{,}875 \times 140}{55} = 1{,}603{,}318 \ B.t.u.$$

to raise it from zero to 140 deg. final temperature. The heater should be 28 pipes in depth, and will give off 1600 B.t.u. per sq.ft. It will require

$$1{,}603{,}318 \div 1600 = 1002 \ sq.ft.$$

of surface, with

$$1002 \div 28 = 36 \ sq.ft.$$

per section. From Table 4, this corresponds to a 4x5-ft. section, which has a free area of

$$4 \times 5 \times 0.4 = 8 \ sq.ft.$$

and permits an air velocity of

$$\frac{629{,}875}{60 \times 8} = 1312 \ ft. \ per \ min.$$

This is within the limits.

In like manner the forge shop is found to require a heater 28 pipes deep, made up of 3x3-ft. sections, and containing 400 sq.ft. of surface.

The total air supply for the office wing of the building is 1,302,000 cu.ft. per hr., and is to be raised to 70 deg. in zero weather. This will require a heater 12 pipes deep containing

$$\frac{1{,}302{,}000 \times 70}{55 \times 2000} = 828 \ sq.ft.$$

of surface. This should be made up of 6x6½-ft. sections to give the required surface and area for air flow. Another article will deal with the arrangement of these fans and heaters together with air distribution, piping details at heaters, etc.

Blind and Blank Flanges—The words "blind" and "blank" are often erroneously used in connection with flanges. A blind flange is to close the end of a pipe, while a blank flange is not drilled but in all other respects is complete. The words "blank flange" are sometimes used to designate a pipe flange which is not threaded, though this is poor usage.

A Remarkable Stream—Deschutes River, Oregon, a tributary of the Columbia, is unique. Its natural flow is remarkably constant. In times of so called floods it rises only a few inches, because, for a considerable part of its course it flows through a region of lava and loose volcanic material which act as a huge sponge. The headwaters of the river afford such large and well distributed reservoir sites that the total flow of the river may be utilized both for irrigation and for power. The irrigable lands in the valley aggregate 300,000 to 500,000 acres. Below this area the river flows in a deep Cañon having a fair slope and affording excellent opportunities for power development. A reliable water supply is assured by the return waters from the irrigated areas above, a large part of the water seeping back into the channel, and by the lower tributaries of the river. The United States Geological Survey has just issued a comprehensive report discussing the river's possibilities. The investigations of power resources indicate that after allowing for irrigation, a total of 600,000 hp. may be developed. A copy of the report, which is published as Water-Supply Paper 344, may be obtained free on application to the Director, United States Geological Survey, Washington, D. C.

OVER THE SPILLWAY

JUST JESTS, JABS, JOSHES AND JUMBLES

This week we'll just jest, jab and josh with Prosperity, all the way down the column. Have a few jumbles with your Uncle Billy!

Fifteen thousand employees of the Lynn works of the General Electric Co. are now working full time. Three days a week were all they were getting. Prosperity's on the job.

Hard times and trouble? Not when 75,000 cheerful idiots can warm up to a football match on a cold fall day.

1 Football — 3 Highballs + Enthusiasm = 75,000 Happy Souls.

And old Prosperity went down in his jeans for it!

Despite the inroads of the typewriter, the fountain-pen industry has trebled in these United States in ten years. Prosperity's pen is mightier than the typewriter. Proof? Give a glimpse at the "Correspondence" pages this week.

Perhaps your employer will be far more prosperous when you are able to advise him in any contemplated purchase of new equipment. Even now he may be waiting for you to come forward and go to it. Other engineers have been well repaid for this welcome service; why not you, son?

There is a Prosperity movement on foot to make the 1915 wheat crop a record-breaker. Bully! Here's hoping that our factories and shops, our power plants and our business houses execute a similar foot movement and bust a few records. And—oh, let it be soon!

A Vermont lad 89 years young has, in the exuberance of his youth, given up smoking. Having had that habit for the past 70 years, he's turned over a new (tobacco) leaf. If any of you 89-year-old engineers think this habit stands in the way of old man Prosperity getting you, give it up. We're going to—when we're 89.

Why are the operating engineers, the boiler manufacturers, the American Society of Mechanical Engineers working on a standard type of boiler if not for their mutual Prosperity?

The time is near at hand when the retardation and stagnation of our waterpower resources will give way to healthy development; when the public lands will go to bona fide homeseekers; when our waters will be used for navigation, irrigation and power; when timber will be cut to build homes, schoolhouses and power plants—and then old man Prosperity will be chucking you and I under our chins!

To cite a few instances, why have we recently built a centrifugal pump with a capacity of 100 million gallons per 24 hr.; a twin-tandem compound geared reversing engine developing 25,000 hp.; a boiler carrying a load of 11,000 kw. per hour; a jet condenser condensing 150,000 lb of steam per hour; a 10,000-hp. turbine weighing a million pounds?

Because the wonder of yesterday is but a commonplace today; because big business necessitates big developments—because Mister Prosperity needs 'em in his business in order to live up to his name!

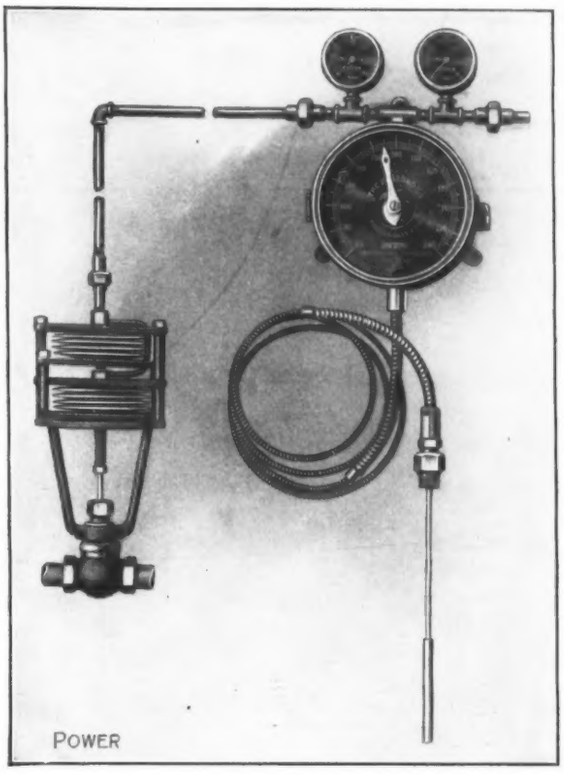
But, shucks! we won't prosper, too, unless we prod ourselves into something like activity—and keep a-prodding! When the good things come our way we've got to be prepared to grab 'em by the coattails and swarm up into the band wagon at the head of the parade. Let's help make the dust, and not straggle along at the tail-end of the procession and be compelled to swallow it. You're hep, ain't you? Sure! Then—

Hooray for Prosperity!

Foxboro Temperature Regulator

This new controller has three principal parts, the bulb, the controller proper and the diaphragm valve. The bulb may be made of brass, copper or steel, depending upon the chemical action of the liquids or vapors with which it comes in contact. Its size and shape may be made to fit the requirements of the apparatus or room the temperature of which is to be controlled.

The bulb is filled either with liquid, gas or liquid and vapor. The pressure in the bulb, due to the change in the temperature surrounding it, is transmitted to the interior of the controller case through a capillary tube protected by a flexible tubing, as shown in the illustration. The capillary tubing inside the case is connected to a hermetically sealed helical spring; therefore, the pressure in the bulb is transmitted to the spring and gives motion to it.



FOXBORO TEMPERATURE REGULATOR

Through proper connections, the helical spring operates a small valve contained in a part of the casting projecting through the top of the controller case. The motion of the spring actuates this valve and allows the pressure or vacuum, depending upon which system is used, to enter the piping at the left of the controller, this piping being connected to the diaphragm valve.

The diaphragm-controlled valve is inserted in the pipe line supplying heat to the device the temperature of which is being controlled and is opened or closed by the action of the diaphragms. The number of diaphragms depends upon the pressure against which the valve operates. Where pressures are over a few pounds the valve is balanced, therefore the number of diaphragms does not become excessive. The diaphragm valve has no rubber

parts as it is made of metal; it may be had in sizes up to 12 in.

The small gage at the right of the controller indicates the amount of pressure or vacuum maintained by the supply system; the gage on the left indicates when and how much pressure or vacuum is used to operate the diaphragm valve. The working parts inside the controller case are few and simple.

The recorder is manufactured by the Industrial Instrument Co., Foxboro, Mass.

Winslow High-Pressure Boiler

SYNOPSIS—A new high-pressure boiler of the wet-tube type designed to operate at pressures up to 600 lb. and 300 deg. of superheat. Virtually it is a water-tube boiler, without drums, made up of removable sections consisting of a number of small tubes welded into headers. Due to small storage of energy and the small tubes, the boiler has a large margin of safety. Advantages claimed are concentration and a higher overall efficiency for the power plant.

For over four years the Winslow Safety High Pressure Boiler Co., Chicago, Ill., has been experimenting on a high-pressure boiler with the original intention of applying it to automobile truck and tractor service and later to any field requiring steam at high pressure. Essentially it is a water-tube boiler without the drums, made up of a number of individual elements each consisting of a bank of tubes welded into headers. The elements are arranged vertically, and as many as are needed to make up the capacity are placed side by side over the boiler furnace. At the top each element connects with a common steam header and at the bottom with a mud pipe and a tap from the feed-water supply (Fig. 1).

Due to the relatively small tubes employed, it is claimed that pressures up to 2000 lb. can be safely generated, but 600 lb. is about the limit for the lubricants and materials of construction available for the prime mover. This is the highest pressure the company intends to use for power-plant service. As there are no large drums and only small storage of energy, there need be no apprehensions about the safety of the boiler. The rupture of a small tube should not prove serious, and this is about all that could happen in the present design.

Construction of Boiler

Referring to Fig. 1, one of the elements is shown in position, the others being in line behind it. The form of the section and its connection to the steam header *A*, mud pipe *B* and the feed pipe *C* will be apparent. It will be noticed that the tubes are inclined, the front ends being higher than the rear, and proceeding upward the inclination gradually decreases until the top tube is practically horizontal. All of the tubes are slightly bent, so that they may expand considerably under heat without warping out of line. Each section carries a baffle *D* made of cast iron or steel channels filled with plastic refractory material. The baffles of each section come in contact and

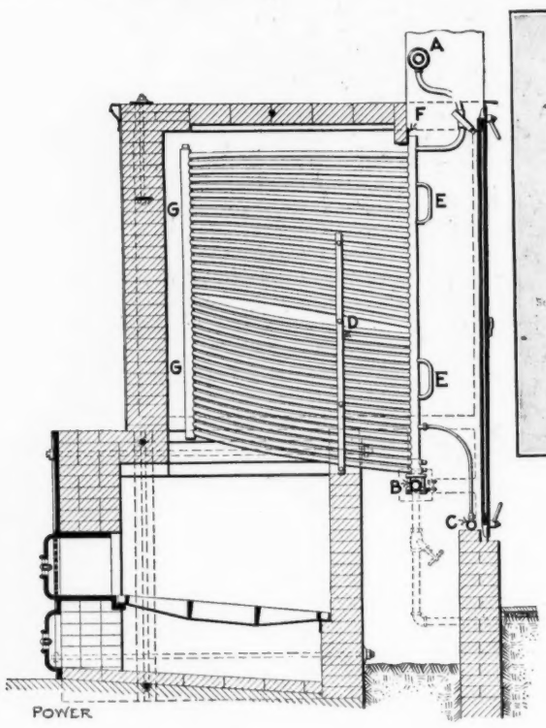


FIG. 1

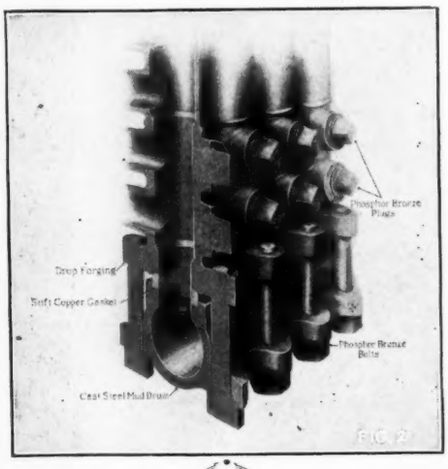


FIG. 2

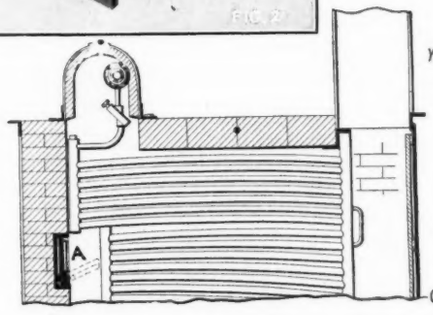


FIG. 3

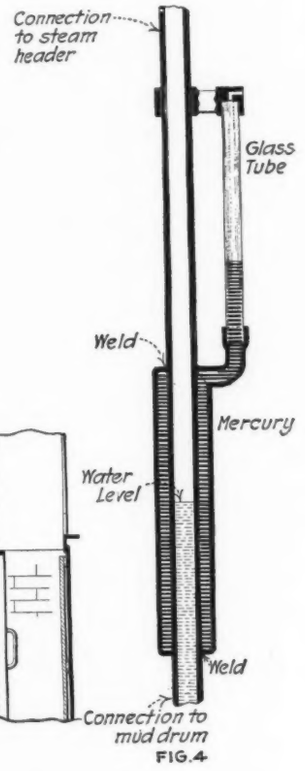


FIG. 4

Fig. 1. Vertical Section through Winslow Boiler. Fig. 2. Lower End of Rear Section Header and Mud Pipe. Fig. 3. Showing Provision Made for High Superheat. Fig. 4. Water-Level Indicator

those on the outside touch the walls of the setting, so that a complete baffle wall is formed, forcing the gases to pass up over the front of the tubes and down at the rear.

From the upper end of each rear section header a steel tube leads to the steam header. This tube is made up in two parts, one welded to each header and both connected to each other by a special joint. The lower end of the rear section header is connected to the mud pipe as indicated in Fig. 2, and opposite the two lower tubes bronze plugs give access for inspection or cleaning. A tap for the feed pipe near the bottom of the rear header is the third connection for each section. These three joints are the only ones which are not welded, and as they are located in the last pass for the gases, the temperature to which they are exposed is comparatively low. The joints are accessible and made with metal-to-metal contact. By breaking these three joints a section can be removed for cleaning or repairs, and the boiler can be maintained in operation without serious inconvenience. The handles *E* are provided to facilitate removal. In putting the sections back in place the forward movement is restricted by the joint at the mud pipe and the angle *F* against which the top of the rear header comes in contact.

Between the front headers and the wall of the setting a small flue space *G* has been provided to lead part of the hot gases from the furnace to the top tubes of each section. This flue is proportioned to give the necessary higher temperatures to the upper tubes for drying and superheating the steam. Where high superheat is desired the upper tubes are made longer and the superheating zone is detached from the zone of water circulation, as shown in Fig. 3. After passing over the superheating tubes the gases unite with the main stream at the top of the baffle and pass downward on their way to the stack over the coldest part of the heating surface. Thus the functions of a boiler, superheater and economizer are combined in one unit.

Due to the high pressures and temperatures, a special water-level indicator is used. It consists of a steel tube surrounded by a steel jacket, the intervening space being filled with mercury. As shown in Fig. 4, a glass tube is fitted into the top of the jacket, to show the level of the mercury. That part of the mercury surrounding steam will absorb more heat than the part exposed to the water. From the average temperature resulting, the mercury will rise to a certain point and thus definitely indicate the water level. The mercury will be high for low water, and *vice versa*. There will be a certain lag in the indication, due to the increment of time necessary to transfer the heat through the metal wall, but this is negligible, as a wide range in water level is permissible without decreasing the safety or the economy of the boiler. When superheated steam is generated a thermometer, usually of the dial form, is used as an additional indicator of the water contents of the boiler.

Action of the Boiler

Reference to Fig. 5 will make clear the action of the boiler. The arrows show the path of the gases, and the circulation is indicated by the different symbols. From the lower tubes the water naturally flows toward the front header, rising in the latter and returning through the upper tubes. The nearer the top, the less the water, until separation is practically complete and only steam is present in the uppermost tubes. The hot gases from the furnace through the front bypass dry this steam and superheat it to a certain degree. As previously mentioned, special provision is made for higher superheat. Due to the rapid circulation from front to rear, much of the suspended matter settles in the mud pipe and is removed through the blowoff.

Cleaning

To clean the tubes inside and out it is proposed to remove the sections and perform the work outside of the boiler. When scale has formed in any of the tubes the usual process of removal consists of mechanical loosening with a copper or pneumatic hammer. The scale is then

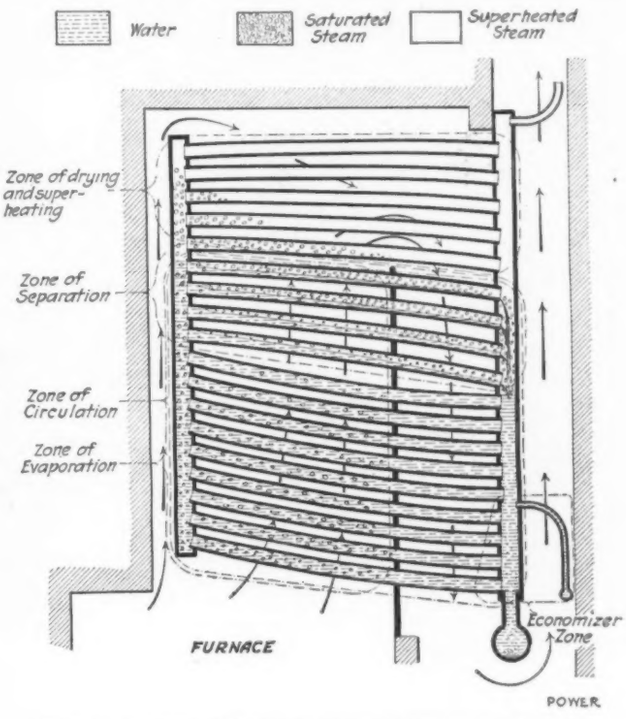


Fig. 5. Sketch Illustrating Action of Boiler

washed out by inserting in the front header a small tube with an outlet near the end, so that the water can discharge into the boiler tubes. Scale has also been loosened by means of a small wood fire. With the section empty the metal expands faster than the scale and the latter is freed from the surface. Any repairs to the section can be made at the same time, but the use of a standard welding outfit is required.

Experimental Boiler

A small boiler has been used for some time on an automobile owned by the company and has given excellent satisfaction. A power boiler has also been set up in the boiler room, and during the past year has been operated at frequent intervals. It is rated at 60 hp. and contains 18 sections 4 ft. long and about 5 ft. high. Each section has thirty-six 1¼-in. tubes, having 0.095-in. walls, welded into 2-in. headers. The total heating surface is 847 sq.ft., or 14 sq.ft. per horsepower of rating. Ordinary flat grates having a surface of 16 sq.ft. are employed. The ratio of heating to grate surface is thus 53 to 1.

The furnace or bottom part of the setting is 8 ft. 3 in. long and 5 ft. 7½ in. wide, making a total of 46.4 sq.ft. of floor space occupied, or 0.77 sq.ft. per horsepower of

rating. The upper part of the setting is 4 ft. 2 in. wide, 6 ft. 1½ in. long and the height from the floor to the top of the setting is 11 ft. Front and side views of the boiler are shown in Fig. 6. At the back the large doors giving access to the sections will be noticed, and at the front and side of the setting the numerous inspection doors.

sures of from 350 to 400 lb., and enough superheat to prevent initial condensation, probably about 100 deg. On engines of small power operating on a vacuum of 27 in. a rate of from 11 to 12 lb. per indicated horsepower-hour is expected, and noncondensing, a water consumption below 17 lb. In larger units operating with high superheat and vacuum, water rates close to 8 lb. per indicated horse-

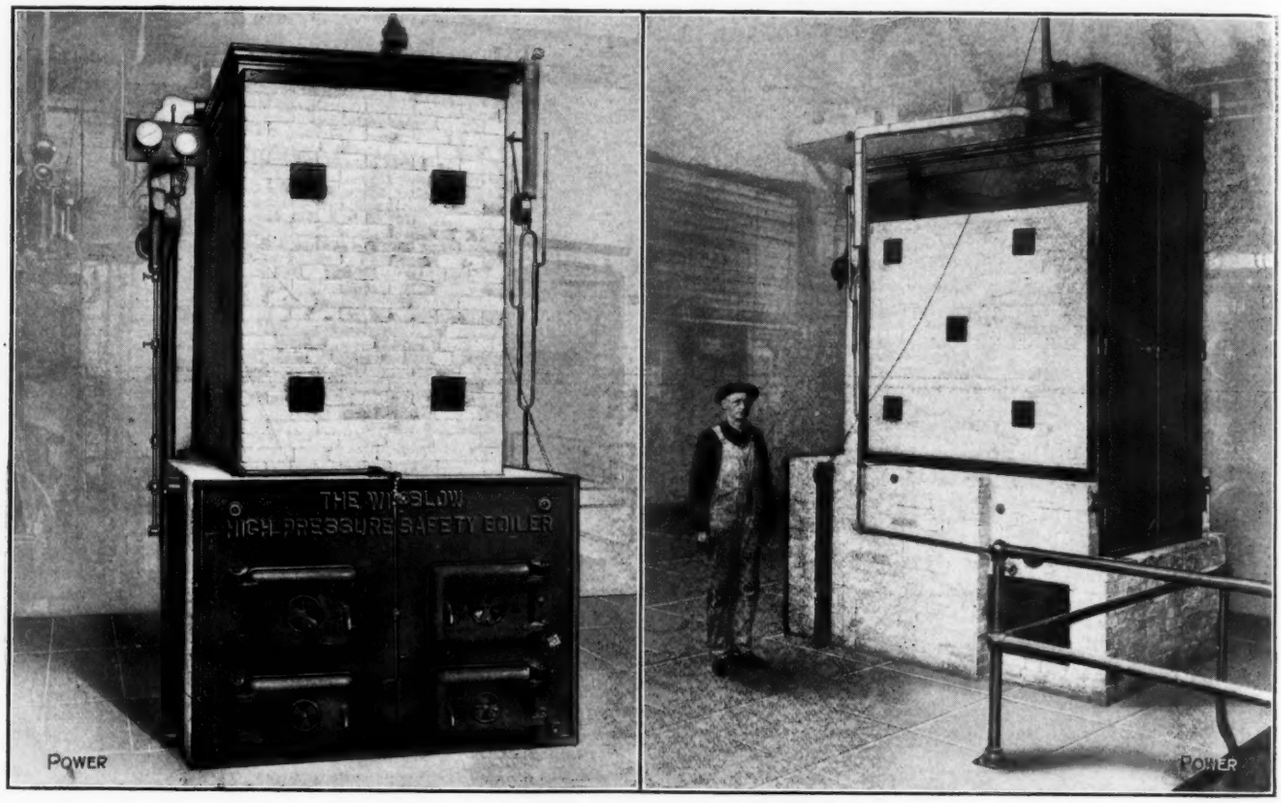


FIG. 6. FRONT AND SIDE VIEWS OF EXPERIMENTAL BOILER

In this boiler, which was built for demonstration purposes, pressures up to 500 lb. have been carried and in the sections a superheat of 283 deg. has been obtained. Working under average conditions at 350 lb. and 200 deg. superheat, the boiler easily evaporates 8 lb. of water per pound of Pocahontas coal. The efficiency is, of course, largely a matter of furnace design.

With the sections filled, the boiler will hold 1080 lb. of water, and when three-quarters full, the normal condition, 810 lb. During the evaporation test referred to, 1900 lb. of steam per hour was drawn from the boiler. Dividing by 847, the total heating and superheating surface gives an evaporation of 2.24 lb. per sq.ft. of surface. Other tests were conducted to demonstrate the control over the boiler. Drawing steam at the above rate and with the fire burning briskly, the steam outlet was suddenly closed, the furnace door opened, and the result was an increase in pressure of from 10 to 15 lb. As a matter of fact, with so large a factor of safety, the safety valve would be set considerably above the working pressure and prevent undue waste of steam.

Arrangements have already been made to build engines and boilers for portable machinery and entrance into the power-plant field is anticipated. The engines are to be of the single-acting, unaflow type designed under the supervision of Prof. Stumpf. They will be operated at pres-

power-hour have been reported for the unaflow engine. The foregoing mentioned combination then has possibilities worth investigating.

Coon Rapids Development

On Nov. 16, at a meeting of the Western Society of Engineers held in the interests of the Hydraulic, Sanitary and Municipal Section, J. W. Link, hydraulic engineer of H. M. Byllesby & Co., read a paper on "The Coon Rapids Low-Head Hydro-Electric Development on the Mississippi River."

This plant is equipped with five 2100-hp., single-runner waterwheels operating on an average head of 17.5 ft., and eventually it will have two more units of the same size. From Government stream-flow data for the years 1905 to 1913 inclusive, an annual average of 64,000,000 kw.-hr. may be expected from the seven units and 52,000,000 kw.-hr. from the five units installed. It is intended to use the water up to the full capacity of the equipment and, in connection with other water and steam plants under Byllesby control, to supply the demands of Minneapolis and St. Paul.

Mr. Link dwelt particularly on the interesting features of the construction work under the general heads of Hydrology, Borings, General Layout of Plant, Construction Camp, Foundations and Forms. Numerous lantern slides were shown, and of these the views showing methods of bracing and the large scroll case forms were of particular interest. A brief summary of the hydraulic and electrical equipment concluded the paper. As part of it supplements the article which appeared in "Power," June 30, 1914, it is given in the following:

The generating units are of the vertical type, each consisting of an Allis-Chalmers single-runner Francis turbine directly connected to a General Electric alternator and fitted

with a roller thrust bearing and an oil pressure governor. The turbine runner, having a mean diameter of 8 ft. 6½ in. and a diameter over the discharge ring of 12 ft. 8 in., is set in a concrete scroll case with cast-iron pit rings. The wheel gates, which control openings 54 in. high by 13 in. wide, are of the swivel type with exterior operating ring and links. The rotating element of the machine is carried by a roller thrust bearing which rests on the upper spider of the generator. The length of the shaft from the center of the runner to the top of the roller bearing is 21 ft. 6 in. A water-lubricated lignum-vitæ guide bearing is carried by the upper cover plate of the turbine, and an oil-lubricated guide bearing is carried by the upper spider of the generator just below the roller thrust bearing. The shaft has a flanged coupling 3 ft. 7 in. above the lower guide bearing.

The roller bearing and the upper guide bearing are lubricated by a unit oiling system. The oil filter, storage tank and circulating pump are in the wheel pit. The motor-driven rotary circulating pump is mounted on the oil tank and forces the oil up to the bearings. The return of the oil to the filter is by gravity. The governor head and governor oil pump are driven by belts from a countershaft, which in turn is driven by bevel gears from the turbine main shaft.

The generator is a 1625-kv.-a., 2300-volt, 62-r.p.m. three-phase, 60-cycle machine, the rotor of which is 17 ft. 4 in. in diameter. The maximum load on the roller bearing, due to the weight of the rotating parts and to the downward thrust of the water, is 170,000 lb. Excitation of the alternators is furnished by two 300-kw., 720-r.p.m. motor-generator sets. A fifteen-panel switchboard provides the means for controlling the station.

For transmission to Minneapolis the current is stepped up to 13,200 volts by two banks of 1375-kv.-a., 60-cycle, single-phase, water-cooled transformers. The exciters, transformers and switchboard are located in compartments on the downstream side of the station and at the same elevation as the floor of the generator room. In a gallery over these compartments are the oil switches and lightning arresters. The transmission line consists of two circuits of 250,000 circ.mils solid copper wire, carried on cedar poles with wooden crossarms.

In detail, construction and general arrangement the entire equipment is so simple, strong and accessible that it is confidently expected that the operating and maintenance costs will be low. Arrangements are being made to determine the efficiency of the hydraulic turbines. High economy is anticipated.

Low-Pressure Turbines in Steel Mills*

By F. G. Cutler†

SYNOPSIS—Describes the savings made at the Ensley, Ala., steel works of the Tennessee Coal, Iron & Railroad Co., by using low-pressure turbines for furnishing air for blast purposes.

In hardly any other way has the reduction of operating costs in steel works been excelled, at least in relative values, than by the lowering of power costs and the saving effected by displacement of labor made possible by cheaper power.

This had been done by the installation of gas-engine-driven blowing engines and gas-engine-driven generators, motors on rolling mills to displace engines (which must necessarily have had sufficient capacity to handle the maximum load, and thus have been operating generally at an uneconomical load), together with the elimination of their attendant standby losses; also by the connecting of boiler houses by steam lines to utilize excess furnace gas and allow the shutting down of uneconomical boilers and the operation of others at a more economical load.

Other examples are the condensers on noncondensing units and improvements in economy of existing units by apparatus of higher economy, such as low- or mixed-pressure turbines.

REDUCTION OF POWER COST AT ENSLEY

A striking example of the possibilities of the last mentioned plan is afforded by the Ensley plant of the Tennessee Coal, Iron & R.R. Co. At the time of its acquisition by the corporation, this plant (consisting of six blast furnaces, 11 open-hearth furnaces, a blooming mill, a rail mill and shops) had seven boiler houses and two electric power stations, with a total rated capacity of 1800 kw. A third power station of 1800 kw. capacity had just been completed. All of the engines operated noncondensing, and no power was supplied to the outside plants. Additional electric power was required, and it was also necessary to materially increase the blowing capacity at the blast furnaces. All of this apparatus having been operated noncondensing, low-pressure turbines were of particular advantage, in that no change in engine conditions was needed.

By using low-pressure turbo-generators and low-pressure turbo-blowers with condensers and cooling towers at the blast-furnace blowing-engine house, two boiler plants have been dismantled, another at the local pumping station operates only occasionally, and two more at the steel plant are operated only during the time the mills are rolling, being shut down over Sunday, when the furnace boilers supply all the steam. All electric power is supplied for the operation of the American Steel & Wire byproduct plant at Fairfield and all that required to operate seven coal mines in the neighborhood of Ensley, resulting in the shutting down of several boiler plants and a reduction in load on others. Besides, the Birmingham, Ensley & Bessemer street railway is also supplied with power for the operation of 25 cars on 32 miles of single track.

This has been accompanied by an increase of product and a reduction in coal consumption. The saving in coal with the present equipment and methods of operating over former practice is estimated to be at the rate of 200,000 tons per annum.

LOW-PRESSURE TURBINES AT ENSLEY

Inasmuch as this is perhaps the largest equipment of low-pressure turbines in a steel plant in the country, it is appropriate to briefly describe the equipment and discuss the results obtained.

In the No. 2 power house, adjacent to the rail mill, are three 300-kw., 25-cycle, three-phase, 6600-volt generators operating at 1500 r.p.m., and driven by mixed-pressure turbines supplied with exhaust steam through five regenerators, each 8 in. diameter by 50 in. long, from two 55x66-in. twin reversing engines and a 52x72-in. corliss engine. Steam from the pressure pumps and air compressor (after the feed water heaters are supplied) is utilized for power.

The capacity of these regenerators is sufficient to absorb the extreme fluctuations in steam delivery. Under conditions requiring the use of all available low-pressure steam, there is no loss of exhaust steam at the back-pressure valves over long periods. This is accomplished without raising the back pressure on the engines over about four pounds.

At the No. 1 power house, near the blast furnaces, are three 3000-kw., 25-cycle, three-phase, 6600-volt generators and one corliss engine driving a 2000-kw., 6600-volt generator, the exhaust of these reciprocating engines being connected to a 3000-kw. mixed-pressure turbine similar to the three units in No. 2 power house, no regenerator being necessary on account of the relatively steady load. These two stations are operated in parallel and the load is divided between the two according to steam conditions.

TURBO-BLOWERS AT THE BLAST FURNACE

The turbo-blower equipment at the blast furnace consists of two mixed-pressure turbo-blowers, each of 55,000 cu.ft. per min. capacity, taking exhaust steam from 16 long cross-head-type vertical reciprocating blowing-engines, the air tubs of which have corliss inlet and poppet discharge valves, and one mixed-pressure, turbine-driven blower of 45,000 cu.ft. per min. capacity, taking steam from seven similar blowing engines. The last mentioned turbo-blower was originally a high-pressure, turbine-driven machine.

STEAM CONSUMPTION TESTS

To check the steam saved by the use of turbo-blowers, it is necessary to know the consumption of the original equipment. A test was made on five blowing engines; the principal

*Excerpts from a paper entitled "The Use of Steam Turbines for Various Purposes," read at the October meeting of the American Iron and Steel Institute.

†Chief of bureau of steam engineering, Tennessee Coal, Iron & R.R. Co.

data are given. The actual blast delivery was taken as 307.5 cu.ft. per revolution, as shown by previous calculations, the indicated horsepower, however, was based on indicator diagram results.

HEAT BALANCE TEST: STEAM CONSUMPTION OF BLOWING ENGINES

	R.p.m.	Blast Pressure Lb.	Volume of Blast at 307.5 Cu.Ft. per Revolution
Engine No. 20	35.2	15.81	10,825
Engine No. 22	41.7	15.81	12,830
Engine No. 23	43.4	11.11	13,350
Engine No. 24	35.4	11.11	10,890
Engine No. 25	32.3	11.11	9,940
Total	188.0		57,835
Total cu.ft. blast against		15.81	23,655
Total cu.ft. blast against		11.11	34,180
Indicated horsepower			3,473
Heat equivalent of work per hour, i.hp. × 2545			8,838,000
Radiation			49,500
Heat rejected above hotwell temperature, 2,000,000 lb. × (114.5 — 83)			63,000,000
Steam 142.7-lb. gage vacuum, 26.51 in. Quality, 98.5 per cent. Heat per pound above hotwell temperature B.t.u.			1,098.5
Pounds steam supplied to engines per hour			65,435
Dry steam supplied to engines per hour			64,450
Pounds steam per i.hp. of steam cylinders			18.5
Blast per min. at 15 lb. (23,655 × 1.01418) + (34,180 × 0.7855) cu.ft.			51,500

Steam per 100 cu.ft. at 15 lb. = 2.09 lb.

The steam consumption of 2.09 lb. per 100 cu.ft. of blast at 15 lb. is about 3 lb. condensing, corresponding to a gross saving of 30 per cent. by these blowing engines being run condensing.

The latent heat in one pound of exhaust steam at 26.5 in. vacuum is 1024.4 B.t.u., and as approximately 957 B.t.u. per lb. of steam is given to the condensing water, the quality of the engine exhaust to the condenser in the above tests was about 93.4 per cent. The use of 3 lb. of steam per 100 cu.ft. of blast corresponds to 27 lb. steam per i.hp., this figure being checked by tests of the steam plants in the past, which give an efficiency as compared to the Rankine cycle of 54.5 per cent. By the use of the Mollier diagram, the quality of the exhaust steam from these noncondensing engines is found to be about 95 per cent.

On this basis, 3 lb. of dry steam delivered to the engines per 100 cu.ft. of blast would furnish 2.85 lb. dry exhaust steam, which in the turbo-blower would give

$$\frac{2.85}{307} \times 100 = 93 \text{ cu.ft.}$$

of blast; both engines and blower delivered against 15-lb. blast pressure.

SAVING FROM USE OF TURBO-BLOWERS

With blowing engines operating noncondensing, as was formerly the case at Ensley, a 30 per cent. saving in steam was made by condensing; by operating the same engines noncondensing and utilizing the exhaust steam in low-pressure turbo-blowers, a gross saving over original noncondensing conditions of about 93 per cent. was made, thus making the saving by the installation of turbo-blowers over condensing operation about 48 per cent. Local conditions requiring the use of cooling towers modify these figures somewhat, although the relative saving is not greatly different.

In summer, when the test was made, water from the cooling towers had a temperature of 95 deg., so that it was hardly possible to materially improve the vacuum of 26.64 in. With 28-in. vacuum, which it is possible to maintain with 75 deg. injection water available during the winter, the steam consumption of the low-pressure turbine would be improved at least 16 per cent., reducing the steam per 100 cu.ft. blast to 2.65 lb. This means that from the exhaust steam of the reciprocating, noncondensing blowing engines used in turbo-blowers exhausting into condensers at 28-in. vacuum, the actual blast delivery of these engines would be increased 113 per cent. For an average vacuum of 27.3 in., the actual blast delivery is practically double that of the noncondensing engines. In other words, from the steam used to blow three blast furnaces with high-pressure, noncondensing engines, three additional furnaces are blown by means of low-pressure turbo-blowers.

The term "blast unit," which is the blowing of 1,606,140 cu.ft. of blast against 15 lb. pressure, has been used as a unit of delivered power of blowing engines, and is the equivalent of the generation of 1000 kw.-hr. At Ensley, the cost per blast unit is $2.50 and is equivalent to a steam cost of one-quarter of a cent per kilowatt-hour.

USE OF TURBINES IN BYPRODUCT WORKS

The operation of turbo-blowers and exhausters in byproduct work is a comparatively recent service. The Tennessee company was the first to install them in this country, and probably the first anywhere to use them exclusively.

At the byproduct plant at Fairfield, there are five two-stage exhausters, each of 9,000,000 cu.ft. capacity in 24 hr., driven by three-stage, high-pressure turbines. Also at this plant there are two, three-stage, high-pressure turbo-boosters, one of 24,000,000 and one of 28,000,000 cu.ft. capacity, one operating at a time. With the usual type of apparatus, a much larger byproduct building and heavier foundations would have been required. The experience of nearly three years' operation has justified the claim that this type of apparatus has a lower operating cost for labor, repairs and lubricants, as well as steam; and with the exception of trouble with shaft packing, due to the action of gas on the metal used originally, the installation has been successful in every way.

There is a peculiar advantage in the use of turbo-exhausters in byproduct service, in that the centrifugal action of the blower throws out the small particles of tar or tar fog carried with the gas, greatly reducing the work required of the tar extractors, which are located between the exhausters and the saturators. Three per cent. of the total tar production of the plant is recovered from the drains on the turbo-exhausters.

English Mechanical Engineers' Refrigeration Report

The refrigeration research committee of the Institution of Mechanical Engineers, England, made its report at the October meeting, an abstract of which follows:

The most important part of the report is that which relates to the standard that should be used for the practical rating of refrigerating machines as a means of expressing the amount of refrigerating effect which the machine is capable of producing under specified conditions. For the purpose of practical rating, engineers are concerned not directly with the limit of temperature of the working substance, but with the temperatures external to the machine between which the heat is pumped. In the normal case of a machine working under steady conditions to keep brine cold by extracting heat from it and discharging the heat to cooler water, the temperatures to be considered for the purpose of rating are four, the upper and lower temperatures of the brine and the upper and lower temperatures of the cooling water.

For rating purposes, definite values have to be assigned to these four temperatures. The following are considered to be suitable for adoption as standard values:

For brine, upper limit, 0 deg. C., 32 deg. F. Lower limit, minus 5 deg. C., 23 deg. F.

For cooling water, upper limit, 20 deg. C., 68 deg. F. Lower limit, 15 deg. C., 59 deg. F.

In specifying the standard conditions, the range through which the brine is cooled (5 deg. C.) has been made somewhat wider than usual, with the object of facilitating the accurate measurement of refrigerating effect in tests made for the purpose of rating. Relative to the method of specifying the amount of heat extracted per unit of time, the committee has considered the practice occasionally resorted to of using a unit based on the making of ice from water at 0 deg. C. or at some arbitrarily chosen temperature. It is of the opinion that the objections to such a method of rating are so serious that it cannot recommend it. Any rating on an ice-making basis is likely to be confused with the actual output of a machine employed in the manufacture of ice, which may be very different. The committee arrived at the conclusion that the most simple and unambiguous form of statement would be to express the cooling effect of a machine in calories per second, the calorie being the amount of heat required to change the temperature of 1 kg. of water by 1 deg. C. One calorie is

$$2.2046 \times {}^{9}/_{5} = 3.9683 \text{ B.t.u.}$$

One calorie per second is therefore equivalent to

$$3.9683 \times 60 \times 60 \times 24$$

or about 342,862 B.t.u. per day; 288,000 B.t.u. per day as a unit of refrigerating effect is recognized in the United States, and it has been suggested that 322,000 B.t.u. be used as a British standard. It will be seen therefore that the calorie per second is a unit of much the same order of magnitude, only slightly larger.

The committee accordingly recommended: First, that the refrigeration produced by a refrigerating machine be expressed in calories per second. This unit is equivalent to 342,862 B.t.u. per day of 24 hours. Second, that the refrigeration may be stated for particular conditions or for standard conditions. Third, that the standard conditions be defined as follows: The temperature limits to be steady; the temperature of the cooling water to range from 15 deg. C. (59 deg. F.) at inlet to 20 deg. C. (68 deg. F.) at outlet, and the temperature of the brine to range from 0 deg. C. (32 deg.

F.) to —5 deg. C. (23 deg. F.). Fourth, that the refrigeration produced under standard conditions be called the rated capacity of the machine.

In cases of cooling by direct expansion without the use of brine, the same method of rating will apply except that the condition has to be modified by specifying for the lower limit of temperature that of the working substance itself. It is considered that a temperature of —10 deg. C. (14 deg. F.) as a lower limit for the working substance will harmonize with the conditions which have to be laid down for machines using brine, and this figure will also be in accordance with the standards of the temperatures adopted by the Association Francaise du Froid. The committee accordingly recommends that in the rating of a direct-expansion refrigerating machine, the temperature of the vapor in the evaporator be taken at —10 deg. C., and that the conditions as regards cooling water be the same as those laid down for machines using brine.

B.T.U. CALORIE EQUIVALENTS FOR DIFFERENT UNITS OF TIME

	B.t.u. per Sec.	B.t.u. per Min.	B.t.u. per Hr.	B.t.u. per Day	Cal. per Sec.	Cal. per Min.	Cal. per Hr.	Cal. per Day
B.t.u. per sec.	1	60	3600	86,400	0.2519958	15.1197480	907.18488	21,772.43712
B.t.u. per min.	0.01667	1	60	1,440	0.0419993	0.2519958	15.119748	362.873952
B.t.u. per hr.	0.000278	0.1667	1	24	0.00069999	0.0419993	0.2519958	6.0478992
B.t.u. per day	0.00001151	0.0000695	0.04167	1	0.0002916	0.0017499	0.1049922	0.2519958
Cal. per sec.	3.96832	238.0992	14,285.952	342,862.848	1	60	3600	86,400
Cal. per min.	0.066105	3.96832	238.0992	571.438	0.01667	1	60	1,440
Cal. per hr.	0.0011023	0.666138	3.96832	95.2397	0.000278	0.1667	1	24
Cal. per day	0.0000459	0.0660960	0.165240	3.96832	0.00001151	0.0000695	0.04167	1

1 calorie = 3.96832 1 B.t.u. = 0.2519958

The accompanying table gives the calorie equivalent of the B.t.u. for time periods varying from 1 sec. to 1 day. It will be found useful in calculating the capacities of refrigerating machines on the basis recommended by the committee.

The theoretical performanec in a vapor compression machine using any assigned working substance assumes adiabatic compression to take place between constant pressure limits of suction and discharge. These two pressures must be known, also the temperature to which the working fluid may be cooled before passing the expansion valve. With these three data there will be for any working substance some particular degree of dryness—i.e., some particular proportion of vapor to liquid at the beginning of compression which with adiabatic action will theoretically be best in the sense of giving the maximum coefficient of performance in the ideal cycle. When the degree of dryness at the beginning of compression is determined, the temperature of superheating reached at the end of compression follows. The essential data therefore for determining the ideal cycle are the suction and discharge pressures, and the temperature before the expansion valve, if the cycle is specified as that which, with those temperatures assigned, will give the highest coefficient of performance in adiabatic action. Further, in order to secure the highest ideal efficiency, the working substance should be cooled before passing the expansion valve to a temperature as nearly as possible equal to that of the supply of cooling water. It is therefore proposed in all cases to take the temperature at which cooling water is supplied as the temperature to which the working substance is supposed to be cooled before passing the expansion valve in calculating the ideal cycle of comparison.

It is accordingly recommended that the ideal cycle to be adopted as a standard for comparison with actual performances be the most efficient cycle employing adiabatic compression in which the pressure of suction and condensation are the same as those that occur in the actual process of working, and in which the substance is cooled before passing the expansion valve to a temperature equal to that at which in the actual process the cooling water is supplied. The pressures should be measured just after and just before the substance passes through the expansion valve.

This last recommendation is required to make the conditions for compression definite in cases where there is any substantial drop in pressure between the compressor delivery and the expansion valve, or between the lower side of the expansion valve and the compressor intake. In some refrigerating machines, the action is compound in that compression occurs in two stages, with cooling of the substance between the two, or the expansion by throttling takes place in two stages with a return of part of the substance to the compressor after the first stage.

The committee does not consider it necessary or advisable to complicate the use of a standard cycle of comparison by specifying ideal cycles special to such operation. It thinks it better that any actual machine employing such a compound process for getting an augmented efficiency should still have its performance compared with that of the ideal machine using the standard cycle. The coefficient of ideal performance C is found by dividing the heat taken in by the work expended in the standard cycle. Similarly, the coefficient of actual performance Ca is found by dividing the refrigerating effect actually produced by the work expended in driving the compressor in the real performance of the machine. The ratio $\frac{Ca}{C_i}$ is a fraction which shows how nearly the real performance approaches the standard idea, therefore this ratio may be called a relative efficiency.

The coefficient of actual performance is found by direct measurement of the refrigerating effect produced in actual working and of the work expended. The work may be reckoned either as the indicated work done in the compressor or as the total work required to drive it. As the indicated work is materially less, it is important in all statements of actual performance that one states clearly which of the two methods of reckoning is employed.

Pan-American Scientific Congress

The United States, through its Department of State, has invited all the governments of this hemisphere to a Pan-American Scientific Congress to be held in the City of Washington in October, 1915. This is the second congress, the first one having been held in Santiago, Chile, Dec. 5, 1908.

Judging from the previous congress, this one will presumably have departments of Pure and Applied Mathematics, Physical and Chemical Sciences; another group of Anthropology, Ethnology, Zoölogy and Botany, Geology and related subjects; on Engineering; on Medical Science and Hygiene; on the Juridical Sciences, and then possibly something on History, International Law, Pedagogy, Agronomy and Zoötechnics, etc.

The Department of State has invited the five national engineering societies, civil, mining, electrical, naval architects and mechanical engineers to assist in the preparation of the program on Engineering. This assistance should be more comprehensive than simply preparing a technical program; it should include the suggestions of the authors, the suggestion of the names of the biggest men in the engineering field in the different countries, and then urge directly or indirectly, through our various affiliations, technically, commercially and diplomatically, the appointment by the various governments of these men of affairs as delegates to the congress; then, after getting them here, it should be seen that adequate reception is provided by the industrial concerns of America, whether leading to the cultural relations between the countries of North, South and Central America, the development of mutual confidence, or, from the American point of view, the development of the confidence of the other countries in our manufactured products, so that when these delegates return, the commerce in our products could be reasonably expected. This feature is mentioned with bluntness and frankness because there is nothing undignified in the parallel program outlined of

(a) A scientic congress, and

(b) The incidental visits to the industries.

On the contrary, we would gain not only in the attendance on the one, but in the benefits of the other by openly enhancing the attractiveness of the program of the technical congress by the practical features of the industrial business. Further, by showing exactly what we have in mind, we ought to get the active interest of the men of affairs in this nation in a matter that has been dragging along for four or five years.

Precautions When Heat Is Applied To Ammonia Drums—Engineers who have the habit of pouring hot water over the ammonia shipping drums to facilitate charging the ammonia into the system and those who have a steam jet to impinge against the drum, or wrap cloth around the drum and stick the end of the steam hose under the cloth should avoid closing the valve on the pipe connection between the shipping drum and the charging pipe while the drum is hot or the drum will probably explode.

BOOKS RECEIVED

STEAM POWER PLANTS—By Charles L. Hubbard. McGraw-Hill Book Co., New York. Cloth; 299 pages, 6x9 in.; 183 illustrations: tables. Price, $2.50.

HEATING AND VENTILATING PLANTS—By Charles L. Hubbard. McGraw-Hill Book Co., New York. Cloth; 308 pages, 6x9 in.; 207 illustrations; tables. Price, $2.50.

NEW PUBLICATIONS

OIL FUEL FOR STEAM BOILERS. By Rufus T. Strohm. Published by McGraw-Hill Book Co., New York, 1914. Size 4½x7 inches; 139 pages; illustrated. Price $1.

This little book forms one of the "Power Handbook Series" and is a practical discussion of the essentials of oil-fuel practice as applied to stationary steam boilers. The subject is handled under the following divisions: Properties of Oil Fuel, Requirements for Efficient Burning, Methods of Spraying, Burners, Cleaning of Oil Fuel, Pumping and Heating, Oil-Burning Furnaces, Installation of Burners, Storage of Oil; Management of Oil-Burning Plants, Purchase of Oil, and Advantages and Disadvantages of Oil Fuel. While the results of a few tests are given, the number might have been increased and thus given the book more value as a work of reference.

ELECTRIC MOTORS. By Francis B. Crocker and Morton Arendt. Second Edition. Published by D. Van Nostrand Co., New York, 1914: Size 6x9 in.; 300 pages; illustrated. Price, $2.50.

As a reference book on the characteristics and applications of electric motors of various types, it has few equals. No attempt has been made to go into questions of design, the treatment being essentially from the operating standpoint. Nevertheless, it is not in any sense an elementary treatise, and, although theory has been subordinated to practical considerations, the book will find its greatest field among students, electrical engineers and operating engineers who already possess a grounding in electricity.

MARINE BOILER MANAGEMENT AND CONSTRUCTION. By C. E. Stromeyer, M. Inst. C. E., Fourth Edition. Longmans, Green & Co., London, New York, Bombay and Calcutta; 1914; 6x9; 410 pages; illustrated; cloth; $4 net.

One could hardly have a better training for an appointed test than has Mr. Stromeyer for the production of a book upon boilers. To an adequate technical training, signalized by a membership in the council of the National Physical Laboratory at Kew, he adds years of service as engineer surveyor to Lloyd's Register, which probably accounts for the "Marine" in the title, and more recently has been chief engineer of the Manchester Steam Users' Association for the Prevention of Boiler Explosions.

The work was issued originally in 1893, the present being its fourth edition. Notwithstanding the title, it is not exclusively nor even principally of value to marine engineers. After the first chapter, Boiler Management, is finished, the builder and user of stationary boilers will find as much of value in his field as will the marine engineer in his own line. The present edition has been revised to take account of recent experimental researches, among which may be mentioned those of Stefan and Bolzmann upon radiation, which seem to explain why the high-temperature flames which are associated with perfect combustion lead to furnace troubles; Nicholson's experiments on the influence of the speed of gas on its heat transmission; Coker's optical measurements of strain, and the author's own experiments on the fatigue of metals, on brittleness caused by the presence of nitrogen in steel, on water-hammer in steam pipes, and the exhaustive experiments of Heyn and Bauer on corrosion. The rules of Lloyd's Register and the Board of Trade, together with tables based thereon, are given in extenso in the concluding chapters.

LESSONS IN MECHANICS FOR MARINE ENGINEERS AND ENGINEERING STUDENTS—By A. N. Somerscales, late lecturer in Steam, Mechanics and Mechanical Engineering at the Hull Young People's Institute. Published by James Munro & Co., Ltd., Glasgow, Scotland; D. Van Nostrand Co., 25 Park Place, New York. Size, 4½x7½ in.; pages, 272; cloth binding; illustrated. Price, $1.50.

Like many another textbook, this one grew out of a series of lessons prepared for a certain class of students for whom there seems to be no appropriate work already published. The lessons were originally for the evening classes of students at the Hull Young People's Institute and were an attempt to teach the groundwork of applied mechanics without using any mathematics beyond arithmetic. It was with a similar purpose in view that "Power's" Engineering Study Course in Elementary Mechanics was written. It is interesting to compare the two for this reason, but this is not the purpose of the present review. The book would, however, appeal to those who followed our course and might prove a beneficial means of further grounding the study of the elements of the subject.

In this book, to take the place of algebraic and trigonometrical demonstrations of the principles, simple experiments are described. The examples and exercises were selected especially for marine engineers, but the treatment is such as to interest engineers of all kinds.

COMPRESSED AIR PRACTICE—By Frank Richards. Published by McGraw-Hill Book Co., New York. Size, 6x9 in.; 326 pages; 96 illustrations. Cloth. Price, $3.

Only a small proportion of the material of the author's book "Compressed Air," which made its appearance about fifteen years ago, is to be recognized in the present volume and with an improvement in the method of treatment. Definitions and general information on the properties of air and an explanation of the compressed air problem are given in a manner that will be appreciated by those who know little about the subject or who may have despaired of gaining knowledge from authors who have too frequently appeared to regard the subject as an arena for the display of mathematics.

The author's treatment is confined to simple arithmetical and algebraical methods of computation, the work being intended "for those who know little about air rather than for those who mostly know all that is known," and "those who need more accurate and detailed information for practical guidance may perhaps derive some hints of how it may be obtained."

Tables and diagrams are given for computations of compressed air and separate chapters are devoted to the use of the indicator, single-stage, two-stage and three-stage compression, and on the various methods of compressing air; also on power cost, power from compressed air, the air lift and other methods of employing compressed air for raising water and on the leading practical applications, the last chapter being devoted to liquid air and the separation of oxygen from the atmosphere.

The illustrations are good, and although the work treats of latest improvements in machinery for compressing air, it is exceptionally free from catalog literature.

TECHNICAL MECHANICS. By Edward R. Maurer, professor of mechanics in the University of Wisconsin. 6x9 in., 363 pages. Price, $2.50. Published by Wiley & Sons.

This book is intended to illustrate only those principles of mechanics applicable to engineering problems, without giving an excess of detail relative to the construction of the machine or mechanism itself. The work is divided into two parts—Statics, consisting of six chapters, and Dynamics, which comprises the latter part of the book. This arrangement is to be commended, as the subject of statics is simpler and further because the mind of the average student grasps the idea of rest more readily than that of motion.

An exceptionally good feature is the collection of problems placed at the end of the text; in fact, throughout the work the principles are clearly illustrated by practical examples, demonstrating the fact that fundamental principles can only be grasped by the analysis and solution of many problems. The subject of statics is so presented that the more important parts may be mastered by anyone with a fair knowledge of trigonometry.

In the first chapter the author goes into considerable detail to explain the composition and resolution of forces. The next chapter gives the general conditions of equilibrium for all possible combinations of forces, and in the following chapter these principles are applied to the various forms of roof trusses and cranes so as to give an excellent opportunity for introducing graphical statics.

Unless the student is well up in his mathematics, he may find that part of the work dealing with dynamics considerably more difficult. The chapter on work, power and energy contains practical information relative to train resistance, drawbar pull, cylinder effort and other items relating to the motion of trains.

The book is the result of the author's experience for a number of years in the use of the former edition, and should, therefore, eliminate many of the objections usually found with works on mechanics, and it should prove of great help, both as a text and as a reference book.

Bad Effects of Leaks in Steam Mains—Leaks in steam mains may short circuit the electrical connections. They also cause doors to swell and damage the adjoining woodwork.